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The Month.

Caissons in Bridge Building.—In the paper read before the Society of Arts, Professor Oliver, M.D., presents a very useful summary of the physiological aspects of engineering work prosecuted by the aid of compressed air. At Newcastle-on-Tyne, where the author gained his experience of compressed-air illness in connection with the building of the new high-level bridge over the river Tyne, the three caissons employed in excavating for the pier foundations were of sufficient size to accommodate 35 men at one time. These chambers measured 113 ft. long by 35 ft. wide by 9 ft. 6 in. high. Of 150 men engaged in the operations 48 men worked for 267 days without ill effects, 29 men worked for 180 days and remained in good health, and 49 men worked for 90 days without developing unfavourable symptoms. This satisfactory record is no doubt due to the stringent precautions adopted, but there is reason for believing that the same degree of care is not universally shown in the manipulation of caissons. The object of Professor Oliver's paper is to emphasise the most salient points for observance by those who are in charge of such appliances. Nothing more than somewhat unpleasant sensations are experienced during "compression" in the air-lock, and presuming an abundant supply of fresh air no detrimental effects are to be anticipated in the working chamber. The critical period is that passed in the air-lock during "de-compression," and more especially after the process has been completed. While the air pressure is being relaxed in the lock the fall of temperature is very great and may be as much as 40° Fahr., thus exposing the men to the risk of chill, but the most prejudicial effects are experienced when and after de-compression has been hurried. Professor Oliver points out that employers in Holland adopt the humane policy of providing each man with a blanket shawl, of warming the air-lock by electricity, and of paying for all time spent in the lock. In this way the men are reconciled to the increased duration of the de-compression process, which is more protracted in Holland than in most other countries. After discussing the questions of air supply, the length of shift, and the symptomatology, physiology, and pathology of caisson disease, the author concludes with some notes on the prevention and treatment of the disorder. As nitrogen absorbed by the blood and liquids of the body seems to play the most important part in the symptomatology of caisson disease, the longer a man is immersed in compressed air, and the higher the pressure to which he is exposed, the greater must be the amount of gas absorbed, and, consequently, the shorter the shift and the

longer the time spent in de-compression. The duration of this process has an important effect on the cost of a contract, and in the interest of the men as well as of conscientious contractors it should be regulated by law in accordance with the length of shift and the pressure. At Newcastle only one minute was allowed for de-compression to every 5 lb. air pressure, which is very little when compared with forty minutes to 30 lb. pressure allowed in Holland, and with the following recommendations of Hill and Macleod as quoted by Professor Oliver :—

Pressure.	Shift.	De-compression.
lb. per sq. in.	hours.	hours.
30	4	½—1
45—60	4	1—2
75	1	1—2
90—105	½—1	2

Other points to be remembered by the engineer are (1) that men employed in caisson work should not be addicted to alcohol, subject to catarrh, or have a weak heart or lungs; (2) that the most suitable age for such work is from twenty to thirty years, and (3) that men of spare habit are less liable to caisson disease and can work better than those of stout build. In conclusion, Professor Oliver expressed the opinion that if pure air is supplied to the men and plenty of it and the shifts are not too long, there is not the least doubt that work in compressed air could be carried on at greater depths and under higher pressures than has hitherto been attempted, so that, should occasion demand, engineering operations of even greater dimensions than any previously contemplated could be undertaken and carried to a successful issue, from the point of view of the health and safety of the workers.

The Channel Tunnel.—Encouraged by the hope that in the Parliament now assembled at Westminster the view is widely entertained that the construction of the Channel Tunnel would be an unmixed advantage alike to Great Britain and to France, the promoters of that project are about to bring forward a resolution declaring the expediency of allowing experimental work to be resumed. Considering the cordial relations existing between ourselves and our neighbours across the Channel, it is by no means improbable that the motion will be adopted, and in that event the next step will be the deposition of plans and sections in readiness for the introduction of a Bill in 1907, to take the opinion of Parliament upon the advisability of sanctioning the completion of the undertaking. There is a unanimous consensus of opinion to the effect that direct railway communication between Great Britain and the Continent would be advantageous to all concerned, and particularly to British manufacturers and traders. One objection urged against the scheme is that in spite of the belief expressed by some geological experts to the contrary, it is not absolutely certain that an uninterrupted bed of impervious material exists between the two sides of the Channel. If the stratum of chalky marl through which it is proposed to drive the tunnel should prove to be separated somewhere in mid-channel by a fault admitting water in considerable quantities, or if the infiltration of water should take place to such an extent as to render necessary the employment of compressed air, the project could not be carried to a successful conclusion by any known method, for at the depths involved the pressure of air required would be far beyond the endurance of man. The point here raised is one that can best be tested by driving a pilot heading from side to side, and we feel sure that the completion of this preliminary work would not only be wise as a precautionary measure, but as a matter of policy for the purpose of encouraging prospective shareholders in the venture. Another objection is that which was raised by the military authorities against the former Bill in 1883. Of course, we must not dismiss lightly any opinions on this point when they are offered by modern experts, but having regard to the simple arrangements that could be made for the annihilation of any trainload of hostile soldiery brought to the English end of the tunnel, and for the instant blocking of the work by flooding and blasting to prevent any further incursion, we cannot but think the fears once entertained as to the possibility of a successful invasion were altogether exaggerated.

New Facts about Eye-Bars.—The results of the tests made by Mr. Theodore Cooper in connection with the building of the Quebec cantilever bridge have aroused widespread interest in Canada and the United States, and it is indeed extraordinary that no one should have discovered the liability of eye-bars to be permanently elongated in the pin hole as the result of very moderate strain in the body of the bars themselves. Mr. Cooper's tests show a

permanent set at a strain of about 12,000 lb. per sq. in., the elastic limit of the metal being about 35,000 lb. per sq. in. This is a striking confirmation of the deduction made by Professor Bauschinger that after a strain is once applied, the consequent elongation is never entirely eliminated, although it may gradually decrease after an interval of rest. In view of the results obtained by Mr. Cooper, it is clear that the present design of eye-bar heads is defective, especially as the modern tendency is towards reduction in size. Two general conclusions from these tests are very evident. One is that eye-bars must be made with larger heads, and the other that the use of harder steel is desirable. The annealing of eye-bars and the importance of conducting this operation under scientifically-correct conditions are other matters that clearly deserve most careful attention, and it would be a move in the right direction to abolish the rough and ready colour test in favour of pyrometric measurement for guidance in the control of temperatures during the process of annealing.

The Flaming Arc.—A useful contribution to existing literature on long-flame arc lamps is to be found in the paper read before the Institution of Electrical Engineers by Mr. Leonard Andrews. In our "Note" on p. 158, we pointed out that lamps of this type give from five to ten times as much light per watt as an ordinary arc lamp. This general statement is fully sustained by Table II. in the paper, which has been calculated by making the necessary corrections for globes and different standards of illumination. Mr. Andrews directs attention chiefly to the "Carbone arc" which was exhibited about three years ago at Hastings, and since then has been extensively adopted in Berlin with much success. The author lays particular emphasis on the whiteness of the light given by this lamp, and although in the subsequent discussion Mr. Trotter suggested that this quality might be only apparent the substantial advantage to the users is not less real. The only disadvantage of the flaming arc is to be found in the poisonous nature of the fumes emitted, but this is a feature which does not militate against the usefulness of chemical carbon lamps in the open air, or even in well-ventilated rooms.

The Motor Boat at Monaco.—From the absence of sensational incidents at the recent motor boat race meeting, it is evident that the design of this type of vessel has fully entered upon the practical stage of development, and from the splendid success which attended the "Yarrow-Napier" boat, notwithstanding injury through the rough weather encountered on the voyage to Monaco, it is clear that British engineering skill has not been turned in vain to the latest form of naval architecture. It was at first thought that the hull of the Yarrow-Napier was so badly damaged as to be beyond repair, but having been hurriedly patched up, she was able to complete the 50-kilometre course on the second day of the meeting, winning the race against the leading Continental boats in the 8-12 metre class. Subsequently, in the big handicap she secured a victory against all competing craft, a success which was the more remarkable because, owing to the critical condition of her hull, it was not possible to run the engines at full speed throughout the whole length of the course.

Reinforced Concrete Construction.—Owing to the rapid development of interest in reinforced concrete among engineers within the last year or so, some Continental and American firms of patentees have recently established agencies in this country, doubtless with the object of sharing in the anticipated boom. Hitherto, the work of exploiting concrete-steel as a structural material has devolved chiefly upon one or two well-known pioneers, whose efforts have been rewarded with success not merely from a financial point of view, but also in the respect that all the structures erected have been capable of passing severe tests with satisfactory results, and that many of them have been in use for a sufficient time to give an assurance of continued strength and durability. Now that more active rivalry is about to commence, a word of warning may not be out of place. We all know that one effect of competition is very frequently the tendency to cut down prices, and with them the quality of work or the quantity of material to be used for a given purpose. In the case of reinforced concrete the only directions in which dubious economies can be effected are reduction of the percentage of the reinforcement and of the quality and thickness of the concrete. Continental engineers are accustomed to place far greater reliance upon the resistance of reinforced concrete than British engineers believe to be wise, and the failures that have occurred in the past show that excessive faith in the new material is not justified. The American predilection for cutting things

fine is also well known and needs no comment. So far as reinforced concrete construction has been applied in the United Kingdom, it certainly does not represent flimsy design, but there is no saying what may happen in the future under the stress of competition, if engineers lend too ready an ear to the representations of patentees with much faith in the material-saving properties of their inventions. We have no preference for any one of the numerous systems of construction, but feel strongly that engineers will do wisely to insist upon ample factors of safety in connection with all works they may feel disposed to execute in reinforced concrete.

The Progress of Suction-Producer Plant.—Since Bénier conceived the idea, some ten years ago, of utilising the suction occasioned by the piston of the internal-combustion motor in place of the forced draught necessary in ordinary gas-producing plant, the suction producer has been developed into a practical apparatus of great value and importance to all users of power. As the steam boiler or fan for creating forced draught and the usual gas-holder for the storage of gas under pressure are not required in the latest form of producer, and as the cooler and washer are replaced by a single scrubber, the result is a considerable saving in the cost and installation of the plant, in fuel consumption, and in floor space. So far as concerns fuel, independent testimony proves that the consumption is frequently less than 0·9 lb. of anthracite coal, and from about 1·0 to 1·3 lb. of coke per effective h.-p. per hour. Moreover, the suction apparatus works well with inferior coal containing from 6 to 8 per cent. of volatile matter, and from 8 to 10 per cent. of ash. These favourable conditions account for the welcome universally accorded by power users to the suction-producer, and for the dismay with which it is regarded by some of those who are commercially interested in the coal-gas industry. One of our contemporaries seeks to throw discredit on the apparatus, in a recent article evidently intended to please the makers of ordinary gas. The writer indulges in dark hints as to the troubles which the misguided suction-gas user is to encounter. He is to be poisoned by leakages, his apparatus is to break down and its vaunted simplicity to disappear, and numerous difficulties are ever to plague him. The erratic behaviour and sinful character of the suction-producer are set forth in words of gloomy foreboding, but the greatest sin of the apparatus seems to be its capacity of providing from 10 to 20 b.h.-p. for a fuel consumption of one penny per hour. We hold no brief for the makers of gas-producing plant, and are quite ready to admit that such apparatus has not yet reached perfection, and may be still further improved as years go by. As a matter of fact, it is quite a common thing to find progressive improvement in engineering appliances, and this circumstance need not inspire in power users the alarm which is evidently felt in some quarters. The present status of the new producer may be judged in some measure by the fact that one British firm alone have made fully 30,000 h.-p. of suction-gas plants, and have been obliged to build special works for dealing with this branch of their business. To show that plant of the kind is not entirely in the possession of simple-minded and misguided manufacturers, we may mention the fact that Messrs. G. and J. Weir, of Glasgow, have a 200 b.h.-p. installation supplying seven engines in their works, and that the same type of apparatus is being extensively adopted for the generation of electricity, one of the most recent examples being that installed at the central station of the Calcutta Electric Supply Corporation. It is also the fact, as pointed out in our issue of January, 1906, that suction plants have come so largely into use in the Midlands that the Birmingham Gas Committee have been obliged to reduce their rates for power-gas supplied from the Corporation works.

The Effect of the Gyroscopic Action of Turbine Rotors on Torpedo Boat Design.

BY A. H. GIBSON, B.SC., A.M.Inst.C.E.

FROM the many advantages which appertain to the use of the steam turbine for marine propulsion, and from the large measure of success which has attended those cases in which the substitution of turbines for reciprocating engines has already been tried on a large scale, it appears certain that in the near future the turbine will displace the reciprocating engine as a marine prime mover in very many cases, and notably where large power combined with small weight is above all a desideratum. All vessels of the torpedo boat, or destroyer type, for example, will in all probability be "turbined" rather than "engined," and this substitution of prime movers must naturally influence the design of the hull, in virtue of the fact that the dead weight to be borne is less, while the speed—other things being equal—will in general be increased.

But another factor is now brought into play, which should also influence the design—a factor which has in the past been very largely ignored or only approximately allowed for, and which, though it may safely be ignored in the case of a slow-speed reciprocating engine, should not be lost sight of in the case of a high-speed turbine. This may be termed the gyroscopic effect of the rotating parts.

That this effect may be very far from negligible, and that the forces, due to this, which may be brought to bear upon the hull of the vessel, as well as upon certain parts of the propelling machinery, may become seriously large, will be shown in the course of this paper.

It would be well in the first place to consider why the fact that the rotor of the turbine, in rotating at a high rate of speed, is likely to cause any stresses other than those due to the propelling effect of the turbine, to be brought to bear on the hull of the vessel containing it It is comparatively easy to show this experimentally. If a bicycle wheel mounted on its axis be rotated rapidly, it will be found that a much greater effort is necessary to be applied to the axle, in order to change the place of rotation of the wheel, than is necessary when the wheel is at rest. The more rapid the angular velocity of the wheel about its own axis, and the heavier or larger in diameter the wheel, the greater will be the effort required to cause this secondary rotation about a perpendicular axis, while the effort again becomes greater as the velocity of this secondary rotation is increased.

Considering now the rotor of a large turbine in place of the bicycle wheel, we have a body whose weight is very considerable, while its angular velocity about its own axis is very great—probably about 1,000 revolutions per minute.

The secondary rotation referred to above, about a perpendicular axis, will evidently be necessitated by the pitching of the vessel—not by its rolling—and its magnitude and speed is likely to be greatest in boats of the destroyer type, these boats being notoriously lively in a rough sea, both on account of their comparatively small dimensions and of their fine lines.

Since, too, in this type of boat, the scantlings are cut down to an extreme degree, it is obviously unsafe to neglect the hull stresses caused by the effort necessary to overcome the gyroscopic effect of the turbine rotor, which effort

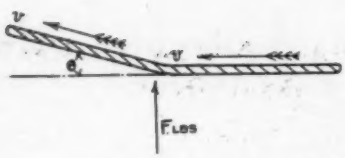


FIG. 1.

can only be transmitted through the hull of the vessel. Its effect will evidently be to increase the bending moment to which the hull is subjected.

It will be remembered that the *Cobra* —one of the first of the high power turbine destroyers built by the British government — broke her back and foundered during a gale in the North Sea a few years ago. This gale, though severe, was not exceptionally so, as was shown by the evidence of the survivors of the disaster. Now of very many destroyers built to the same scantlings for both the British and Japanese governments, and similar in every way to the *Cobra*, except in the fact that their prime movers were reciprocating engines, not one has proved in any way unfitted to bear the stresses caused by the heaviest of seas.

No definite reason was assigned for the disaster by the court of enquiry, but it is extremly probable that the extra hull stresses caused by the gyroscopic effect of the rotors were principally responsible for the disaster.

It is important then, to be able to calculate these stresses, and, in the first place, it must be remembered that if a force act on a body for a given time, changing its velocity in the direction of the force, the change of momentum in the direction of the force will be equal to the force multiplied by the time. Expressed symbolically: $F \times t = \frac{w}{g}(v_1 - v_2)$.

Where F = force in pounds weight.
t = time in seconds.
w = weight of body in pounds.
g = acceleration of gravity = 32 *f.s.s.*
v_1 = final velocity of body at end of time, t.
v_2 = initial velocity of body.
Or $F = \frac{w}{g} \cdot \frac{\delta v}{\delta t}$ = change of momentum per second in direction of force.

For example, suppose an endless rope to hang from a rotating pulley and to rotate with the pulley with a linear velocity v *ft. sec.* Each portion of the rope will assume a definite path, and a considerable effort is necessary to make the rope adopt any other path if v is large. If w lbs. is the weight per foot run of the rope, and if at some point, where the rope is moving in a straight line, a force be applied to deflect the rope through an angle δ, Fig. 1, then if F be the component of this force in a direction perpendicular to the initial direction of the rope, we can find F.

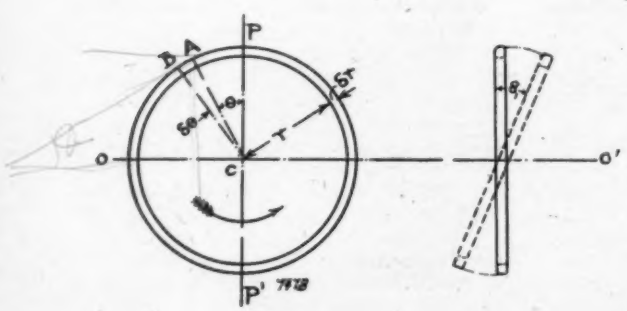


FIG. 2

For:—
Weight of rope passing any point per second = $w\,v$ lbs.
$\therefore$ Momentum in direction of $v = \frac{w\,v^2}{g}$ pound units.
$\therefore$ Final momentum per second in direction of $F = \frac{w v^2}{g}$. Sin δ.
Initial momentum per second in direction of F = zero.
$\therefore$ F = change of momentum per second in direction of $F = \frac{w\,v^2}{g}$. Sin δ lbs.

This is independent of any tension which the rope may have to carry. It is to the fact that an applied force is

always necessary to cause angular displacement of a stream of momentum, that the gyroscopic effect of a rotating body is due. To extend the reasoning to the case of a rotating body, first take the case of a ring of radius r ft. and of thickness—in a radial direction—of δr, its width being b ft.—Fig. (2). Suppose weight of unit volume—1 cubic ft.—of the ring to be ρ, and let the weight of the ring per unit of circumferential length to be W. Suppose the ring to be rotating about its own axis with an angular velocity, w radians per second and to be rotated at the same time about a perpendicular axis oo′ in its own plane, with an angular velocity w^1.

The tendency of the ring itself is to resist by its inertia any such secondary rotation, and to overcome this resistance a couple must be applied to the ring.

To determine the magnitude of the couple in any particular case, consider the mass of the ring (from A to B), subtending an angle $\delta\ \theta$ at the centre (Fig. 2), the angle $P\ O\ Q$ being θ.

The weight of this element $= W\ r\ \delta\ \theta$ lbs. Its velocity $= w\ r$ *ft. sec.*

Now the component of this velocity in a direction parallel to oo′ is unaffected by the rotation about oo′ while the component parallel to $P\ P^1$ *i.e.* $w\ r\ Sin\ \theta$, has its direction changed through an angle w', per second.

The change of momentum then per second, at this point, in a direction perpendicular to the plane of the ring is

$$\frac{W\ r\ \delta\ \theta}{g}\ w\ r\ \text{Sin}\ \theta,\ \text{Sin}\ w'.$$

If w' is comparatively small this may be written—$\frac{W\ r\ \delta\ \theta}{g}\cdot\ w\ r\ w'$, Sin θ.

This then is the magnitude of the accelerating force called into play at this point, to produce the secondary rotation in the element $A\ B$. The moment of this force about oo′ is

$$\frac{W\ r^2\ w\ w^1}{g}\cdot\ \text{Sin}\ \theta\ \text{Cos}\ \delta\ d\theta\ \text{ft. lbs.}$$

Its moment about $P\ P^1$ is $\frac{W\ r^2\ w\ w^1}{g}$. Sin $^2\theta\ \delta\ \theta$ ft. lbs.

Integrating each of these expressions for the whole of the ring, *i.e.* giving θ the limits 2π and o, we find that the couple necessary to cause the secondary rotation is zero about the axis of secondary rotation oo′, and acts about the perpendicular axis $P\ P^1$ in the same plane, its magnitude being $\frac{W\ r^2\ w\ w^1}{g}\cdot\ \pi$ ft. lbs.

If 1 = moment of inertia about this axis pp^1 or oo^1, then $1 = \frac{W}{g} \times 2\ \pi\ r \times \frac{r^2}{2} = \frac{W\ \pi\ r^3}{g}$; and the couple called into play by this secondary rotation is $1\ w\ w$ ft. lbs.

If instead of a ring, we consider a disc of radius "a" ft. and of thickness, "b" ft., we may look upon it as being composed of a series of concentric rings of the type just considered.

Integrating the expression then obtained, between the limits "a" and "o" we get, if W is now the weight of unit circumferential length of an element of unit thickness.

Moment called into play by the gyroscopic action of rotating disc

$$= \frac{W\ w\ w^1\ \pi}{g}\int r^3\ dr$$

$$= \frac{W\ w\ w^1\ \pi\ a^4}{4\ g}\ \text{ft. lbs.}$$

If 1 = moment of inertia of the disc about the axis of secondary rotation,

$$1 = \frac{\pi\ a^2\ W}{g}\cdot\frac{a^2}{4}\ \text{ft. lb. units.}$$

∴ Gyroscopic couple $= 1\ w\ w^1$ ft. lbs.

If 1_0 be the moment of inertia of the rotating mass about the axis of primary rotation the couple will be $\frac{1}{2}\ 1_0\ w\ w^1$ ft. lbs.

If the rotating body be an annular ring of external radius R_1 and internal radius R_2 ft., the couple becomes

$\frac{W\ (R_1^2 + R_2^2)}{4g}\ w\ w^1$, where W = weight of ring in lbs.

Now a turbine rotor of the marine type invariably consists of one or more

annular rings carrying the blades, connected to the propeller shaft by a series of discs, so that the gyroscopic couple for each separate part may be obtained, the sum of these giving the total couple.

It should be noted that in every case this couple, which is wholly due to the gyroscopic action of the rotor, will act about an axis perpendicular to that about which the secondary rotation takes places.

In case then that the rotor of a marine turbine, with horizontal shaft, makes angular oscillations in a vertical plane, due to the pitching of the vessel, in a rough sea, this will call into play a resisting moment acting in a horizontal plane, which will tend to throw the boat out of its course either to port or starboard, according as to whether the bow of the boat is rising or falling, and whether the turbine is rotating in a clockwise, or anti-clockwise direction, when viewed from the bows. This moment will be transmitted through the bearings of the rotor to the hull of the boat, and will tend to cause both side thrust on the bearing and a straining action on the hull itself.

In the case where two similar turbines are mounted side by side driving twin screws, and rotating in opposite directions, these resisting moments will act in different directions, and will, so far as any straining action on the ship's hull, except between the turbines, is concerned, either wholly, or partly, neutralise each other, although the side pressure on the two rotor bearings will still remain. With three turbines, driving three screws, the two outside shafts rotating in opposite directions, and being driven by similar turbines, the gyroscopic effect of the two outer rotors will not affect the hull except that part lying between the two turbines, while that of the middle rotor will do so.

When the vessel, however, is deflected to port or starboard, either when changing its course, or by being struck by a wave coming diagonally across its course, the gyroscopic action of the rotors now causes a moment or series of moments to be called into play, these new moments acting about horizontal axes, and tending to elevate or depress the stern according as the vessel is deflected to port or starboard, and according to the direction of rotation of the rotors. In the case of similar twin screw rotors rotating in opposite directions, the result will be that while the hull as a whole is unaffected, yet a straining action is produced, and rolling will be set up, one side of the stern tending to rise and the other to fall, and *vice versâ*, while with triple rotors the action would be much more complicated. It may be interesting to determine what may be the magnitude of these bending moments, due solely to the gyroscopic action of the rotors, in any particular case.

In the *Cobra*, which was 210 ft. in extreme length, it would be possible, assuming the boat to be riding a sea in which the height of the waves was say 20 ft., their crest velocity being 20 ft. per second, for the maximum angular velocity in a vertical plane to be say one half a radian per second. In this case w would be ·5. Now, the *Cobra* was driven by two high-pressure and two low-pressure turbines driving four propellors, and, assuming that the former rotors have a mean diameter of 3 ft., weighing approximately 8 tons each, while the low-pressure rotors are 5 ft. diameter, with a weight of 14 tons each; taking the revolutions as 1,100 per minute as was approximately the case, we get a gyroscopic couple called into play by each high-pressure rotor, of 10 foot tons, and by each low pressure rotor, one of 38 foot tons.

If the two starboard turbines are arranged to run in the same direction, and in the opposite direction to the port turbines, then due to pitching it would be possible to get a couple called into play, to be resisted by the cross girders and hull between the turbines of 48 foot tons.

If we assume—as seems perfectly possible—that owing to the bow of the boat being swung round by a diagonal wave in a horizontal plane, with the

same instantaneous angular velocity as above, we shall now get a couple of the same magnitude called into play, this time tending to buckle the boat in a perpendicular direction. Should the two high-pressure turbines run in opposite directions, and each low-pressure rotor rotate in the opposite direction to its high-pressure rotor, the maximum couple called into play would now be 28 foot tons—the difference instead of the sum of those due to the two rotors. Should both the port turbines and both starboard turbines rotate together, then the maximum couple called into play would as before be 48 foot tons.

In every case the gyroscopic couple has to be transmitted to the hull or cross-girders of the boat through the turbine main bearings, which should therefore be designed to stand an extra thrust — either vertically upwards — downwards—or sideways—in addition to that due to the weight of the rotor, equivalent to that of the couple. With low-pressure bearings 15 ft. apart, this might amount to $\frac{35}{15}$ tons $= 2\frac{1}{3}$ tons, and would be inconsiderable in comparison with that due to the weight of the rotor.

It should be remembered, too, that the stresses called into play by these couples, are alternately tensile and compressive, and that therefore their effect on the members of the vessel will be twice as great as that due to a statical couple of the same magnitude.

It might be pointed out here that the gyroscopic couple called into play, for every radian per second of secondary angular rotation, in the case of the low-pressure turbine of the *Carmania* would be 15,000 foot tons, and were this turbine to be acting alone, and could this secondary rotation be given to port or starboard, the result would be to elevate or depress the stern of the boat, the effect being as great as if a weight of 22 tons were moved from bow to stern or *vice versâ*.

It is evident then that the gyroscopic stresses are certainly not so small as to be neglected with safety, especially as these become specially important just when, due to labouring in a rough sea, all other stresses are correspondingly increased.

With single-screw turbine boats, the whole of the gyroscopic couple will be transmitted to the hull, which should in consequence be generally strengthened, particularly amidships, to resist buckling both about horizontal and vertical axes. Where twin screws are fitted, the straining action will be more purely local, and will be mainly confined to the portion of the hull in the immediate vicinity of, and lying between the turbines. The girders carrying the turbines—both fore and aft, and particularly those running from port to starboard — should be therefore made amply strong to withstand any such action, and to prevent it as far as possible being transmitted to the hull itself. This, of course, is only possible in its entirety, where the rotors have the same velocity and moment of inertia, and even then the racing of one propellor would cause an extra couple which could not be taken up except by the hull.

With triple screw shafts, the two outer turbines, if similar, will have their gyroscopic couples absorbed to a large extent by a sufficiently strong and stiff system of bed plates and cross girders. Those due to the middle rotor can only be taken up by the hull itself, which should, therefore, be generally strengthened in consequence, particularly in the neighbourhood of the turbines.

With four turbines, arranged symmetrically about the centre line of the boat, the straining action will be least when the two inner turbines rotate in opposite directions, each rotating in the opposite direction to its own outer turbine. Whether this system of rotation is adopted, or whether both inner and outer turbines on the same side rotate in the same direction, the strain will be localised by the adoption of a sufficiently stiff system of foundation plates and girders, and would, if this were properly done, be largely prevented, except in the case of racing of one or more propellers, from affecting the hull.

It has recently been stated in the

columns of the technical press, that the Admiralty, recognizing the fact that the 27-knot destroyers, built after the *Cobra* disaster, would be useless for scouting purposes when opposed to a 25-knot cruiser, especially in a rough sea, have decided in view of the excellent service performed by the old 32-knot boats in the Japanese navy, in the recent war, and in all weathers, to revert to the old type of boat but with turbine propulsion—and with presumably the old scantlings.

In view of this, it should be pointed out that a hull which might prove perfectly satisfactory, when fitted with reciprocating engines—as is the case in the Japanese boats—may be quite inadequate to withstand the stresses caused by turbine propulsion, unless strengthened so as to be capable of bearing due extra stress, due to gyroscopic action. Generally, too, with a well-chosen system of propulsion, the extra weight necessary to provide absolute safety would be so small, if applied at the correct place, as to be practically negligible. It should not be lost sight of, however, that in addition, the gyroscopic effect of the propeller and shaft at high velocities will tend to cause a whipping action in the latter portion of the boat, which should be guarded against by stiffening both the shaft itself and the aft part of the hull. The couple then called into play can, of course, be calculated in exactly the same manner as that due to the turbine rotors themselves.

The Prevention of Coast Erosion.—V.

By Dr. J. S. OWENS, B.A., A.M.Inst.C.E., F.R.G.S.

Masonry Sea Walls.—Masonry is now seldom used alone for this purpose. The face which is exposed to attrition by the sea is often built of stone set in cement mortar, and the core or hearting of the wall of concrete in the mass.

It is difficult to build a wall for this purpose entirely of mass concrete, owing to the face being usually exposed to wave action at some state of the tide, and the consequent difficulties with the shuttering.

About the most suitable arrangement is to construct the exposed sea face with heavy concrete blocks, and to back these with concrete *in situ*. The blocks then do away with the necessity for timbering the face, and are already seasoned when placed in position. They may be themselves faced with stone, such as granite or basalt, to give them a more durable surface. On some parts of the coast, flints are used for the same purpose.

No fixed rules can be laid down as to the best form of sea wall for all cases, each place must be dealt with on its merits, what will suit one place may not suit another; hence the great danger of generalising on such a subject from a small and local experience.

When it is necessary to close a breach in an embankment, through which the water flows every tide; or when a piece of land which is flooded every tide has to be reclaimed, the great difficulty is to get our embankment in position at all. Many methods have been adopted to overcome this difficulty. If we advance our bank from each end, gradually narrowing the gap left in the middle, we produce such a concentration of current through the gap, that it becomes very difficult to keep anything in position there. If, however, we gradually close the breach from the bottom this difficulty is removed.

This can be done in many ways:—By sinking fascine mattresses weighted with stone, by sinking sand bags across the opening, or by driving sheet piles.

The method adopted in closing a breach about 500 feet wide at Youghal, through which the water ran six to seven feet deep at high water, is illustrated in Figs. 7 and 8. A double row of heavy piles, spaced six feet apart, and with eight feet between

the rows, was first driven across the breach; the intervals between these piles were closed by sheet piling, which was not allowed to project more than two feet above the bottom. The main piles were well braced and had raking struts on the land and sea sides.

When the sheeting piles were driven, the space between the rows was filled with earth and rubble, and the timber work then gradually raised by means of a horizontal planking fixed to the main piles. The filling was raised at the same rate as the timber work, an opening being left to allow the escape of the water impounded behind.

FIG. 5.—SEA-WALL AT EAST CLIFF, RAMSGATE, CONSTRUCTED OF FACING BLOCKS WEIGHING ABOUT THREE TONS EACH, AND BACKED WITH MASS CONCRETE. THE STEPS IN THE FACE ARE TOO SMALL TO MODIFY THE EFFECT OF WAVE ACTION.

The author, who was in charge of this work, seized the opportunity given by very low neap tides, which had permitted the the bog to almost empty, and by raising the timber work and filling as the tides became higher with the approaching springs, kept the top always above high water, and completed the closure of the breach. This embankment is now entirely buried in sand, although it stood from twelve to fourteen feet high above the shore on completion, at the deepest parts of the breach. Groynes were run out on the shore in front, and these are also buried for a considerable part of their length.

Attempts had previously been made to close the above breach by throwing sand-bags, but without success, the bags being washed away almost immediately.

Before leaving this part of the subject some mention should be made of the new material, reinforced concrete, as applied to sea walls. It undoubtedly has a great future before it in some forms of sea defences such as groynes, also as a facing for walls and embankments it should be most suitable. It would appear, however, that its sphere of usefulness must be at present limited to such, and to the lighter forms of sea defences, such as breastworks and the like; but whether it can displace the ordinary concrete for sea walls of the usual type the future alone can tell. There appears to be now no doubt as to the perfect protection of the steel by the surrounding concrete when well made.

Turning now to the consideration of wave impact on sea walls, it may be well to point out that such impact is not at all like that of a solid body. This was first shown by Thomas Stevenson, who, while he obtained practically the same pressures for wave impact upon dynamometers having weak springs as when using those with strong springs, demonstrated that this would not be so, if dealing with the impact of a solid body. A cannon ball weighing 32·5 lbs. was dropped from a height of 1 ft.

FIG. 6.—ITALIAN WALL SHOWING RE-CURVED TOP TO THROW THE SPLASH OF THE WAVES SEAWARD.

FIG. 7.—YOUGHAL EMBANKMENT. FIRST ROW OF MAIN PILES DRIVEN. THE FLOODED LAND IS ON THE RIGHT.

FIG. 8.—YOUGHAL EMBANKMENT COMPLETED; TIDE OUT.

upon the discs of two dynamometers, one of which had a spring having a strength of 462·24 and the other of 156 lbs. per in. of elongation. It was found that the dynamometer with the stronger spring registered a pressure of 577·8, and that with the weaker spring 312 lbs., although the force of impact was the same in both.

The impact of a solid body is momentary, whereas that of a wave covers some little time, as each of the particles of water strikes and is deflected.

* Experiments carried out by Captain D. D. Gaillard, Corps of Engineers United States Army, assisted by Mr. J. H. Darling, proved that the pressure due to the impact of an interrupted jet of water, striking a plate normally to the surface, was no greater than that of a continuous jet of the same velocity.

Waves, therefore, must be regarded as exerting a continuous pressure over some period of time, and not a sudden momentary blow, the pressure in fact continuing as long as the wave is in contact with, and advancing upon the structure.

A destructive action is set up as a result of this continued pressure upon a wall with open joints, and containing imprisoned air in the interior. The wave compresses this air by forcing water through the joints, and as the recession of the wave is comparatively sudden when compared with its advance, the pressure is suddenly withdrawn from the outside, which sometimes results in a blowing out of the stones from the face.

This action is not quite the same as that due to hydraulic pressure transmitted through the open joints of a wall or pier, when a wave strikes the face. Unfortunately, however, the final result is the same, the stones being started from the face.

The above indicates why open joints and cracks in a sea wall are such unmitigated evils. It must not be thought that they are the worst faults we have to cope with, they can be avoided by careful construction.

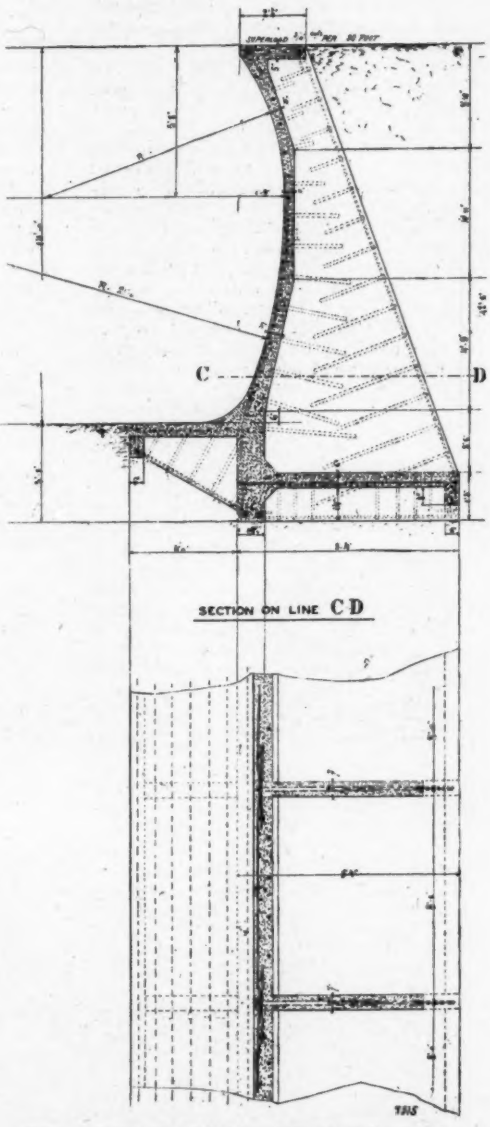


FIG. 9.—SECTION OF A FERRO-CONCRETE SEA-WALL ON THE HENNEBIQUE SYSTEM.

* "Wave Action in Relation to Engineering Structures." By Captain Gaillard, U.S.A., p. 181

There is one insidious evil nearly always lying in wait for the designer and constructor of sea walls for foreshore protection, and that is the scouring out of the foreshore immediately in front of the wall by the rebound of the waves from the face. To avoid this is perhaps the most difficult part of the problem, and one which has never been satisfactorily solved.

On the whole, sea walls have an injurious effect upon the foreshore, especially marked in those which have vertical or nearly vertical faces.

We must always look upon walls as a necessary evil, they do not check erosion in the same sense as groynes do, hence the author has called all structures of this nature "Passive Defences," since they merely resist erosion but do not stop it. It is, indeed, often necessary to erect groynes to protect such walls.

* The following example of the terrible force exerted sometimes by storm waves dates from 1872, and is probably unsurpassed. At Wick Harbour, during a severe storm, a mass of concrete and masonry, weighing not less than 1,350 tons, was seen by the resident engineer being gradually slewed round on the end of the pier by the successive strokes of the waves, until it was finally swept boldly off its foundations and deposited inside the pier.

We can seldom score a victory when we directly oppose the stupendous forces of the sea. It is only when by a careful study of their action we can impress them to our service, or direct some of their energy into harmless channels, that we may entertain a hope of attaining our object.

* "The Design and Construction of Harbours." By Thomas Stevenson.

For some of the illustrations I am indebted to the courtesy of the London Basalt Stone Co. Ltd., and to Mr. L. G. Mouchel, of 2, 5, Victoria Street.

Air in Relation to the Efficiency of Surface Condensers.—II.*

By JAMES A. SMITH.

Effect of Variation of Initial Temperature of Cooling Water.

It is immaterial how the temperature is attained; therefore it may be communicated by an anterior portion of the condenser tube itself.

The problem can now be solved by plotting a curve to an indefinitely long tube, and selecting therefrom a part corresponding to the given tube length; and commencing at that part of the curve where the temperature is the initial temperature required, the final temperature can be ascertained as already explained.

Assume the tube in the diagram to be of indefinite length and immersed in vapour, and that a finite length equal to a given tube is taken at successive points from left to right; the thermal effect is that of supplying warmed circulating water. The mathematical equivalent is the selection of successive terms in a geometric descending series. Therefore, whilst the lateral displacement increases in arithmetical, the tube unit length efficiency decreases in geometric progression.

Example.†—Vapour, steam; temperature, 110°; length, 6 ft. With cooling water at 50°, the temperature increment is 22°; with the initial temperature raised to 90°, the temperature increment sinks to 9°. The work of condensation is directly as these quantities.

By certain properties of the curve (*i.e.*, that ordinates at constant distance apart are in constant ratio to each other, independent of their position in the curve, and that axial progressional motion is equivalent to multiplication), it follows that variation of condenser efficiency, arising from variation of initial water temperature, is independent of tube length.

Example.—Six-foot tube, initial temperatures of 55° and 85°; increments, 23° and $11\frac{1}{2}° = 2:1$. Tube, 12 ft.; temperatures again 55° and 85°; increments, 37° and $18\frac{1}{2}°$; rates, 2 : 1, as before. Therefore in each of these cases the efficiency of each tube, considered as an entity, is halved by a rise of 30° in the circulating water supplied, and the effect is independent of the difference of tube length.

Effect of Variation of Rate of Flow of Cooling Water.

The effects of variation of mixtures and temperatures have been dealt with; it yet remains to consider variation of flow (mass-time dimensions). This cannot be dealt with mathematically, unless some one rate is known, and unless it is assumed that the rate of metallic transmission—and the same factor for water—is either known or is constant. In the absence of this knowledge the writer proceeded by experiment.

In each test the temperature and composition of the mixture were constant, for that test, whilst the rate of flow was varied by steps of $2\frac{1}{2}$ lb., from $2\frac{1}{2}$ lb. to 15 lb. per minute. Fig. 7 illustrates two typical cases. The conditions were:—Vapour temperature, 110°; initial water temperature, 69.5°; in curve *A* nearly pure steam, in curve *B* steam plus 2·22 in. (mercury gauge) of air; 1 sq. ft. of surface, as before. The dots are the observed points.

Discussion of Curves.—The air effect is here, as elsewhere, pronounced.

At very low velocities the flow is non-eddying, and passes through the tubes almost as a solid would, the cooling effect, exercised to a maximum at contact with the tube wall, reaching the axial portion of the mass chiefly by slow conduction. At higher temperatures the motion becomes sinuous or turbulous, intermixture is rapid, and the general effect is greater, not only by the greater mass dealt with, but also by the more effective contact of the component parts of that mass with the tube. Indented tubes, or those of irregular cross-section, accentuate the intermixture.

The variation of rate of curvature in the lines *A* and *B*, Fig. 7, is due, in part, to the variation of the internal motion of the flow. The curves also show that the effect becomes considerably exhausted at quite moderate

* Continued from page 350.

† Verified by direct tests of heated circulating water at 61°, 71·7°, 87·4°, and other initial temperatures.

velocities. The tendency, as the variable becomes inconsiderable, is towards the simple ratio—

Temperature (increment) varies inversely as flow, multiplied by temperature difference.

Duty and Flow.—The work done is dependent upon the mass operated upon, and the temperature increment of that mass. It is expressed as the product of mass into temperature.

Fig. 8 is thus derived from the data of Fig. 7. Curve *A* refers to pure steam, curve *B* to steam plus 0·22 in. (mercury gauge, and at 70°) of added air, in both cases at a temperature of 110°. The divisions of the base denote flow in pounds per minute, those of the perpendicular, B.T.U. per minute per square foot of surface for each total temperature increment (not per degree).

Discussion of Curves.—The air effect is so pronounced that it is scarcely necessary to direct attention to it.

Curve *A* indicates that the work done is not in direct ratio to the flow. The rate of the increment of work is less than the rate of increment of flow, and the proportion is a decreasing one, as the subjoined table shows:—

CURVE A.

Flow in pounds per square foot per minute	5	10	15
Ratio	1	2	3
Thermal units per square foot per minute	100·00	164·000	210·00
Ratio	1·00	1·64	2·10
Ratio per unit of flow	1·00	0·82	0·70

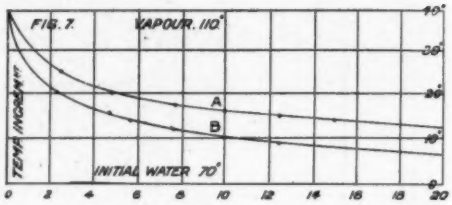
CURVE B.

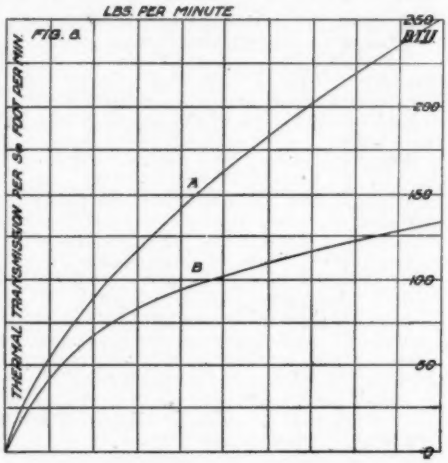
Flow in pounds per square foot per minute	5	10	15
Ratio	1	2	3
Thermal units per square foot per minute	77·00	101·00	117·00
Ratio	1·00	1·31	1·52
Ratio per unit of flow	1·00	0·65	0·51

Apart from static and friction heads, the energy required to produce flow varies as the product of the mass into the velocity squared. Therefore, since the advantage resulting from increased flow is a diminishing one, and the cost of attaining it advances at a rapid rate, a point will be soon attained beyond which it is unwise to pass.

Once velocity has been imparted, it, here, continues—apart from skin friction—indefinitely; therefore a tube of indefinitely great length might be used were it not that it has already been shown that short tubes are relatively the more thermally efficient. The designer must compromise in each particular instance.

As a generalisation, when the steam is





nearly pure—as it must be in future practice—and when the cooling supply is large, and the static head small, short tubes will prove the most efficient.

When it is a case of using an existing condenser, then the mechanical equivalent of increased flow rises at a very rapid rate—*i.e.*, as the third power of the velocity. This results from the preceding equation (power varies as velocity squared for unit mass), and the fact that, as a consequence of the constant sectional area of the tubes, the mass also varies as the velocity. For instance, doubling the flow requires that the power supplied shall be increased eightfold. When there are no means of checking the power abstracted for this end from an installation, it may well be that an increased vacuum is being very dearly bought.

Removal of Gases.

This ranks next in importance to prevention of entry, but the author has no intention of here adding to the discussion of pump design, at present so prominent.

Unless the air is initially removed from the feed by spraying cold through a vacuum chamber, or spraying at boiling point through steam, the introduction of a certain volume of gas in the boiler feed is inevitable, but the amount, including mechanically entrained bubbles, should not exceed about one-thirtieth of the feed volume under ordinary atmospheric conditions. Then, if it is assumed that leakage is entirely absent, and that not more than $\frac{1}{30}$ in. (mercury gauge) partial pressure of air is to be permitted in the condenser, the ratio of effective volume of air pump to boiler feed is one-thirtieth of $(30 \div \frac{1}{30}) : 1 = 20 : 1$. This represents the theoretic minimum for the assumed conditions.

The work of the air-pump is more onerous than when steam partial pressures equalled from 4 in. to 6 in.; then compressions of from $7\frac{1}{2}$ to 5 times determined discharge into the atmosphere at 30 in. Now the compression required may be thirty-fold or more, and any non-effective space becomes a serious consideration, sometimes met by compounding. But compounding does not alter the initial volume of the steam containing the diffused gas requiring to be dealt with. Subsidiary condensation will effect this end if the residual gases be swept from the main condenser by a steam jet, or other means, into a small condenser maintained at the lowest possible temperature. Then the deposition of a portion of the steam, as water, renders the mixture finally presented to the pump richer in air, and smaller in volume; therefore a smaller pump will suffice.

It is obvious that the air-pump must in such case be differentiated from the water-removing pump. Entrained water as hot as, or hotter than, the main condenser would altogether defeat the end sought.

The slowness of gaseous diffusion, compared with the velocity of vapour flow, will prevent the passage backward of the accumulated air from the smaller to the larger condenser, especially if the vapour circulation be forced. The theoretic limit of concentration is reached when the absolute pressure in both condensers is the same, and when that of air in each is the difference between the common pressure and the partial pressures severally due to steam at the respective temperatures.

Experimental Verification.—The condenser used in these experiments, one of about one-thirtieth its vapour capacity, and the mercury gauge were connected in such manner that all could be in communication, or each condenser with the gauge, to the exclusion of the other condenser. Both condensers were boiled clear from air, then air was added to the larger alone. When the temperature of the larger was constant at 110°, and the smaller was at 66°, they were for a short time placed in communication with each other and with the gauge, which showed an absolute pressure measured by 2·75 in. of mercury.

Separated, and tested individually, the readings were as follows:

LARGE CONDENSER.

2·750 absolute pressure in inches of mercury.
2·576 partial pressure due to steam at 110°.

0·174 partial pressure of air at 110°.

SMALL CONDENSER.

2·750 absolute pressure in inches of mercury.
0·639 partial pressure due to steam at 66°.

2·111 partial pressure of air at 66°.

The air had been concentrated in the ratio 2·111 : 0·174, and, under similar conditions, the effective capacity of a connected air-pump would have been increased in like proportion. At 100° and 90° main condenser temperatures equivalent concentration ensued.

Air-Pump Inlets.—It is evident that these should be so multiplied in number, and so situated, that the concentrating air in the vapour will pursue the course of shortest contact with the cooling surface—not, as is too often the case, the longest. No dead spaces should be possible.

Rate of Approach of Steam to a Condensing Surface.

From the known volume of steam at any given temperature, and the rate of condensation per unit surface, this can readily be computed. With pure steam at 140°, and 10 lb. per minate flow, it is in round numbers only about $\frac{2}{3}$ ft. per second. This points to the necessity, not only of exhaust-pipes of large proportions—a point now well recognised—but also of ample inter-tube spaces and passages. The molecular velocity consequent upon change of state upon condensation is not expressed by the preceding. The effect of forced, or blast, impact, and the further effect due to the fact that one side of the tube would then be in "shadow," are subjects for further investigation. It may be noted, parenthetically, that formulæ that express exhaust sectional area as a function of a constant force may be inaccurate. In all reciprocating engines, and some turbines, the acceleration is intermittent, and the area required proportionately greater.

Testing Condensers.

The method of gauge, barometer, and thermometer, needs no further explanation. The warnings may, however, be reiterated that barometers may differ from truth by tenths of an inch, thermometers by several whole degrees, and "Bourdon" gauges by half inches, and that the presence of water, at a temperature differing from that of the vapour, will vitiate the readings in any case.

To obviate the latter source of error, vapour samples received into a boiled-out flask may be tested by gauge at the temperature of the condenser; or the flask may be opened beneath mercury, or water, hot and thoroughly freed from air by boiling. Corrected for vapour tension, the volume unoccupied by fluid determines the air present.

Secondary Condenser Action.

A point that appears to have escaped notice is the effect of the drip from horizontal tubes. It is analogous to jet-condenser action.

At the refrigerating surface the fluid, especially if air be present, will be colder than the vapour; and if sufficient time, equivalent to length of fall, is allowed, this difference will be utilised in cooling the steam and heating the hot-well water.

Land practice has largely followed marine, in which restricted space compels the close centering of the tubes. It remains to be seen whether inter-tube spaces, and the flooding of lower tubes by the drip from the higher cannot be dealt with more efficiently in design.

Possibly the preceding may afford an explanation of the greater efficiency claimed for horizontal as compared with vertical tubes, from which drip does not occur. The experiments given in support of these claims do not, unfortunately, specify the air present, if any; and the omission is important.

Effect of Thickness and Thermal Conductivity of the Walls, and Effect of Tube Diameter,

are subjects worthy of full investigation, and must be determined before a complete theory of the condenser can be enunciated.

Climate.

Passing notice will suffice, although the question is very important, especially in marine work, where the temperature of the cooling water supplied to the same condenser will frequently vary from 40° to 90° or more. It is the limiting factor in high expansion practice. Reference to Fig. 6* will show what is implied in relation to cooling surface, and reference to Fig. 8 what it entails in circulating pump capacity, if the surface is invariable and restricted.

Conclusion.

Gases other than air—itself a merely mechanical association of several gases—alter the co-efficients materially. This has its bearing upon manufacturing processes, but does not affect steam-engine practice. Although no part of the subject can be said to be finally dealt with in this paper, enough may have been shown to stimulate others, who have facilities not possessed by the writer, to carry the matter to a conclusion.

The writer thinks it probable that tube length, diameter, temperature differences, and rate of flow will be found to be expressible by a general law; at times he has thought that he has caught a glimpse of it, but hitherto he has been unable to crystallise it.

The chief conclusions are that:

(*a*) If high vapour vacua are required, air must be excluded.

(*b*) With high vacua climatic conditions are potent limiting factors, and must be specially considered.

(*c*) In the absence of exact knowledge the impossible has been attempted in design.

(*d*) Only by rational condenser proportion will it be possible to push the efficient expansion of steam to those limits that recent improvements in motors seemed to render easy of attainment.

APPENDIX.

Numerical example of the process of plotting a curve with ordinates in geometric ratio between two given ordinates:

DATA.

		Deg.
Steam temperature		110·00
Water temperature	initial	67·00
	final	85·99
Initial steam and water temperature difference (first ordinate or term)		43·00
Final steam and water temperature difference (last ordinate or term)		24·04

* Page 349.

$\frac{\text{(Number of terms}-1)}{\text{last term}}\sqrt{\text{first term}}$ = common ratio = multiplier or divisor of an ordinate giving next succeeding or preceding ordinate.

Let seven terms be required, then, by logs.

$$\frac{7-1}{24{\cdot}04}\sqrt{43{\cdot}00} = \frac{\text{log. of } 43{\cdot}0 - \text{log. of } 24{\cdot}04}{6} =$$

$$\frac{1{\cdot}6334865 - 1{\cdot}3809345}{6} = 0{\cdot}04209 = \text{log.}$$

common ratio ∴

Common ratio = 1·1018.

Feet of Tube.	Term.	Log.	Ordinate.	Successive Differences or Efficiencies.	Cumulative Differences (or Temperature Increment).
0	1	1·6335 0·0421	43·003	00·000,	00·000
1	2	1·5914 0·0421	39·030	3·973,	3·973
2	3	1·5493 0·0421	35·424	3·606,	7·579
3	4	1·5072 0·0421	31·151	3·273,	10·852
4	5	1·4651 0·0421	29·181	2·970,	13·822
5	6	1·4230 0·0421	26·485	2·696,	16·518
6	7	1·3809	24·038	2·447,	18·965

And so on for succeeding decreasing terms. For increasing terms add log. 0·0421 to log. 1·6335, and continue the process. Compare with observed curve, Fig. 6.

Results of Recent Experience in the Bacterial Treatment of Sewage.—V.

By W. H. MAXWELL, A.M.Inst.C.E.

Depth of Percolating Beds.—The amount of purification taking place on percolating beds depends very largely upon the depth of the bed as compared with the rate of flow of sewage on to its surface. Various depths have been adopted in practice, varying from 3 ft. up to about 12 ft., but the most favourable thickness of material appears to lie between 6 ft. and 9 ft. The exigencies of the site area and fall available will, however, usually be the determining factors. Although the larger part of the purification is done in the upper layers of the majority of beds constructed, the deeper beds usually yield the best results. This is largely due to the greater uniformity of treatment to the liquid, due to its passage through the increased depth of material, or, in other words, the irregularities of construction of the shallow bed are to a large extent thus balanced. In a properly constructed and well aërated bed nitrification goes on throughout its depth, but the additional purification attained in depths over 9 ft. or 10 ft. is seldom commensurate with the increased cost, and in very many situations the large fall consumed by these deep beds prohibits their use.

The time occupied by the sewage in passing through even beds of 9 ft. or 10 ft depth is usually very short, and does not exceed some three to five minutes, thus showing that the process of nitrification is an exceedingly rapid one. This view also confirms the desirability of considerably shortening the period of contact and increasing that of rest or aëration.

Aëration of Percolating Filters.—Adequate aëration is provided in percolating filters by simply building up the filtering material upon a concrete flow, having the portion at the centre of the bed raised somewhat for purposes of efficient drainage. Artificial aëration and heating of the bed have been tried, but, in the writer's opinion, may both be safely dispensed with, at any rate so far as this

country is concerned. The temperature of the sewage itself, coupled with the heat generated by the oxidations taking place within the filter, will be found to meet all ordinary requirements. The bed, and, in fact, the whole process of sewage treatment, should be divested of all needless and expensive complications, and be rendered as simple as possible.

The "Contact" and "Percolating" Systems compared.—As the result of the practical experience in bacterial sewage treatment gained during the past decade the preponderance of opinion is decidedly in favour of the necessity for preliminary treatment of the sewage in a sedimentation, septic or reducing tank, but in regard to the mode of final purification of the tank effluent, considerable difference of opinion still exists. Broadly speaking, this latter part of the process hinges upon the comparative merits of the "contact" system as against "percolating beds"—that is, the intermittent holding up of the sewage in contact with the material of the bed, as compared with the continuous trickling or percolating of the liquid over the surfaces of the particles of the bed.

It would appear that the third and last stage of purification should be one of full aëration with nitrification, and that, generally speaking, with the average domestic sewage, the best known method, at the present moment, for bringing about this final result, is in the direction of the continuous passage of the liquid through something akin to the percolating bed. Whilst the contact system, for dealing with considerable quantities, with a minimum of attention, may be wisely adopted for practical reasons of convenience of working, it cannot be denied that the periodic resting-full and resting-empty involves alternate inversion of the bacterial action between the aerobes and the anaerobes, and that this reversal necessarily gives rise to a certain amount of disturbance of a special nitrifying growth, the activity of which is required to be continuous. This condition may be looked upon as a fundamental objection to the contact bed regarded from the theoretical standpoint.

The purification of sewage is not entirely a simple question of oxidation, but is of a much more complex and variable a nature, and it is not improbable that it will always remain impossible to say that either continuous filters or contact beds are universally to be preferred. There is, doubtless, much yet to be learnt as to the precise nature of all the various changes and complicated bacterial and chemical actions which take place in the septic tank, in the contact bed, and in the percolating filter respectively. In some cases it is probable that the denitrification changes as equally important with the nitrification change, and further investigation is required in this connection.

In speaking in his Manchester lecture (March, 1904) of the value of analysis in controlling the work of biological filter beds, whether intermittent or continuous, Dr. Gilbert J. Fowler observed that:

> "This denitrification change is no doubt necessary for the effective oxidation of many substances, *e.g.*, cellulose. In the case of the *contact bed*, the two changes nitrification and denitrification take place alternately, and possibly also simultaneously in the same bed, and consequently, *after double contact, an effluent is obtained where both carbonaceous and nitrogenous organic matters have been well oxidised*. In the case of *continuous filters*, at any rate those of the more open kind, the ammonia is rapidly oxidised to nitric acid, but the conditions do not seem so favourable to carbon oxidation; therefore, these filtrates often have a rather high oxygen absorption and albuminoid ammonia, and incompletely oxidised organic suspended matter passes through, and has to be strained out or settled. During the straining process, some amount of denitrification takes place, and the final effluent, though containing less nitrate, is of greater general purity."

The varying composition of the sewages of different towns, and during different hours of the day in the same town, must ever materially affect the question of the best system to adopt in any given circumstances. The best advice is doubtless to investigate various methods on a small but practical scale, in order that facilities may be afforded for studying the sewage to be dealt with before embarking upon a large and costly scheme. But it is just here that a practical difficulty so generally arises, inasmuch as only a few of the larger local authorities as a rule fully appreciate the necessity for, and advantages accruing from, money spent upon preliminary experimental work.

An excellent idea of the work done on the beds is given by the percentage of purification either as measured by the oxygen absorbed, or by the albuminoid ammonia, and these percentages, for either contact or continuous beds, are very commonly found to lie between 80 and 95 per cent. of total purification on the crude sewage, including the work of the septic tank.

Apart from the question of the degree of purification attained, certain other practical considerations may determine the system of final treatment to be followed. Amongst these, the amount of fall and area of site

available will be important factors. Double contact beds will generally be necessary to secure the degree of purification given by the percolating filter, but the latter will usually require to be of about the same depth as the primary and secondary contact beds together. The effluent from contact beds will contain much less suspended matter than that from the percolating filter, and if the beds are properly constructed and worked, may be turned direct to the final outfall, whilst that from the continuous filter must be passed over pasture land or through a sand filter before being fit to finally discharge.

Any desired degree of purification may be effected by either system, the limit imposed in the one case being the number of contacts employed, and in the other the depth of the filter. If money were no object, a town's sewage may, in fact, be converted back to a wholesome drinking water; but, from a practical standpoint, purification is carried far enough when taken well within the limits of safety appertaining to the case in point, and the true solution of this difficult problem is to bring about this result at the irreducible minimum of cost.

Quantities of Sewage dealt with by Contact and Percolating Beds.—Those strongly favouring the continuous methods frequently urge that much larger quantities of sewage per unit of area can be dealt with by percolating beds than by contact, but any such comparative statement based on area alone will be misleading, as the depth of the bed must in each case be taken into account, and the quantity dealt with should, therefore, be stated at per cubic yard of filtrant. In this respect it is interesting to note that the requirements of the Local Government Board do not recognise any superiority of the continuous filter over the contact-bed or *vice versâ*, and the cubic bulk of filtrant must be the same in both. The maximum volume to be treated per cubic yard of filtrant on either process is calculated at 168·7 gallons, which provides for three fillings per day upon contact beds, or for continuous or intermittent discharge upon the spray or percolating beds. For a bed 4 ft. 6 in. deep this would represent 253 gallons as the maximum volume to be treated per square yard of surface per 24 hours. For a spray filter the depth should not be less than 4 ft., and may advantageously be as much as 10 ft., whilst still deeper beds have been laid down, but extremes in this direction are limited by the exigencies of the site and constructional considerations.

Whilst the foregoing may serve as a basis upon which to calculate the area or volume of beds required in any given case, the quantities actually passed through is oftentimes found to vary considerably either above or below the amount stated, according to the volume of sewage dealt with, but quantities in excess should be avoided as far as possible, as it is difficult to completely recover an overworked bed. In the case of a new bed, for example, two fillings per day will usually be found sufficient until good nitrification is obtained.

On the Exeter contact beds about 800,000 galls. per acre per day is a normal amount, but anything up to about 1,000,000 galls. per day is considered safe working, although much larger quantities have been put on in wet weather. The beds are 5 ft. in depth. At Sutton a 3 ft. coarse bed treated screened sewage at the rate of 750,000 galls. per acre per day, including all rest periods. Also, at Manchester, as the result of experimental work done there, Dr. Fowler considered that the primary beds could be worked at an average speed of three-quarters of a million galls. per acre per day, if the beds are allowed to rest one day out of seven, and one week per month*. At Salford the trickling filters with fixed spray-jet distributors purify about 300 gallons per square yard per 24 hours in dry weather, and about 1,200 gallons in wet weather. At Hanley, with continuous filters fed by travelling distributors, Dr. Reid† reports that "a rate of flow of 200 gallons per yard per 24 hours was decided upon, because experience had shown in the case of other works that such a rate could not be exceeded without greatly reducing the degree of purification obtained. . . ."

* "Royal Commission on Sewage Disposal," Interim Report (1901), Vol. ii., No. 5602.

† Report on "Experimental Disposal Plant" (at Hanley), by Dr. Reid (1904).

(*To be continued.*)

The Efficiency of Surface-Condensers.

By Professor R. L. WEIGHTON, M.A.

THE subject of the efficiency of surface condensers is one which has recently been engrossing the attention of engineers to a considerable degree. Until quite recently it had not been investigated to a degree commensurate with its importance, although to those who had examined the subject at all closely it was evident that the surface condenser as usually designed and worked was not as efficient an apparatus as might be.

The experiments of two recent investigators have done much, however, to advance our knowledge; the masterly research of Mr. Jas. A. Smith* having demonstrated how the presence of air in even minute portions affects the reduction of efficiency, and the very useful results obtained by Prof. Weighton from an exhaustive series of trials pointing the way to valuable modifications in condenser design and proportions.

Prof. Weighton laid the results of his inquiry, in the form of a paper, before the Institution of Naval Architects, of which the following is a substantial reproduction.

The writer had for years back intended to take up the subject experimentally, and about eighteen months ago the opportunity of effectively doing so was at last afforded by a gift to the engineering department of Armstrong College, Newcastle-on-Tyne, of three condensers, which were presented to the college by Messrs. Richardsons, Westgarth & Co., of Hartlepool. They are of a type to which the name "Contraflo" has been given, and embody in their design certain novel features.

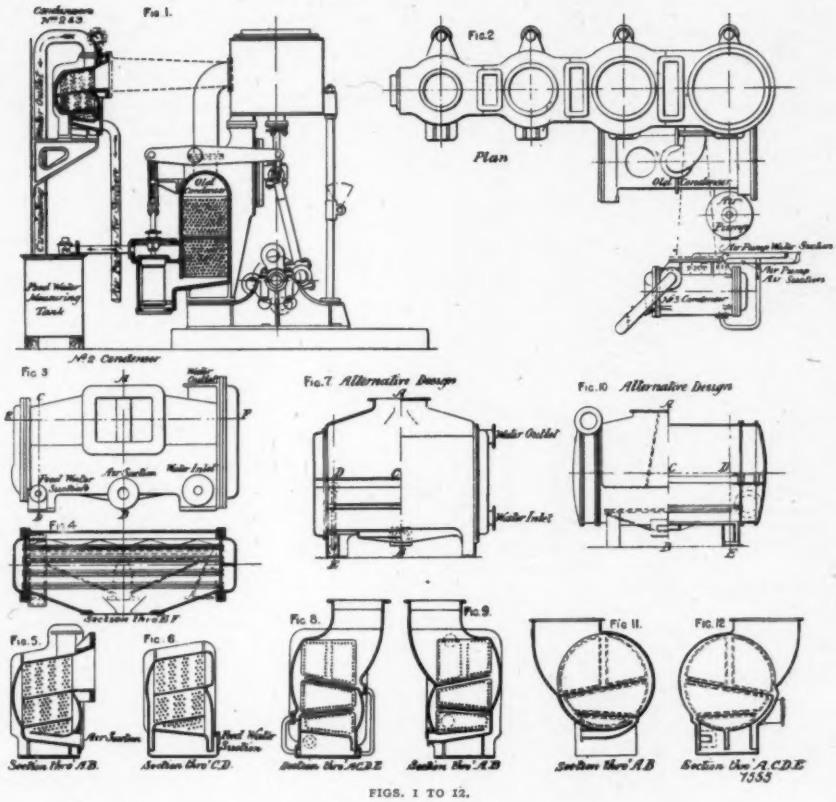
The general question of the efficient action of surface-condensers will be illustrated by reference to results from two types of condensers: first, the type which is generally in use at the present time, and second, the type above referred to as embodying several novel features. For the sake of clearness they will be referred to in what follows as the "Old Type" and Nos. 1, 2, or 3 of the "New Type."

A. *Condensers:*—1. *Old Type.*—Figs. 1 and 2 show the design of this type as used in the experiments. The total condensing surface on the trials was 170 square feet. The tubes are $\frac{3}{4}$ in. in external diameter by 4 ft. long between tube plates, and are pitched $1\frac{7}{16}$ in. centre to centre. The condensing water enters at the bottom and leaves at the top, after circulating twice through the tubes, thus giving an effective tube-length of 8 ft.

2. *New Type.*—No. 1 condenser of this type contains 170 square feet of surface. It has tubes $\frac{3}{4}$ in. in external diameter by 4 ft. long, pitched $1\frac{1}{8}$ in. centre to centre. The condensing water circulates five times through the tubes, thus giving an effective tube-length of 20 ft. This condenser proved itself much too large for even the maximum quantity of steam the engines could take, and No. 2 was, therefore, made, containing only 100 square feet of surface, and having tubes $\frac{5}{8}$ in. in external diameter by 4 ft. long by 1-inch pitch. The water was at first made to circulate eight times, thus giving an effective tube-length of 32 ft. Alterations were subsequently made to the condenser doors, and a circulation of four times was adopted, giving an effective tube-length of 16 ft. No. 2 condenser is shown in Figs. 3 to 6, which figures will serve to illustrate the new type generally. No. 2 condenser proving also of very ample size for the amount of steam available, it was decided to build a still smaller condenser of exactly the same transverse section as No. 2, but with tubes only 2 ft. 6 in. long, giving a surface of 62 square feet. This is No. 3 condenser. It is exactly the same as No. 2 in every respect except in the tube-length. The water circulating four times gives an effective tube-length of 10 ft. A transverse section, which serves for both condensers 2 and 3, is given in Fig. 1 for comparison with the old type. The position of the condensers on trial is also shown in this figure.

It will be noted that a leading feature of

* See pages 341 to 350, and 410 to 414.



FIGS. 1 TO 12.

this type of condenser is compartment-drainage of the feed-water. (See Figs. 3 to 12.) The condenser is divided into three compartments by two diaphragms, somewhat inclined to the horizontal, and the water of condensation in each of the three compartments is drained off directly from that compartment, so that the surfaces in the lower compartments are unimpeded in their condensing action by water from the upper compartment flowing over them. As the major part of the condensation, even at fairly high rates of condensation, is completed in the highest sections of surface on which the steam first impinges, the importance of this feature is apparent, and its influence will be seen on the results.

Other features of the type are the abolition of the steam space, and the substitution of a mere passage of such shape and section as will secure the distribution of the steam over the whole length of the tubes, the tubeless passages connecting the compartments with each other, and, generally, the means adopted for promoting uniformity of flow of vapour over the whole tube-surface, and throughout the whole condenser section.

In Figs. 7 to 9 and Figs. 10 to 12 are shown alternative designs on the same principle for rectangular and circular sections respectively.

B. *Air-Pumps.*—A very large number of trials were made, both on the old and on the new condensers, with the air-pump attached to the condenser of the experimental engines in use. This pump is of the usual vertical single-acting bucket type, driven by levers from the L.P. cross-head, in the fashion common in marine practice, and is 8½ in. in diameter by 9 in. stroke. Throughout these trials the engines were run at a standard speed of 140 revolutions

per minute, thus fixing the pump capacity per unit time. The outline of this pump is shown on Fig. 1. Subsequently it was decided to instal an air-pump driven independently of the main engines, with a view to test the effect on condenser-performance of variations in air-pump capacity, and of working on the so-called "dry" air-pump system.

A set of three-throw vertical air-pumps, electrically driven and of the "Edwards" type, was therefore fitted and connected to the condenser by pipes. Each pump was 8 in. in diameter by 8 in. stroke, and so arranged and fitted as to be capable of being worked single, double, or triple, in series or in parallel, and with or without a cold-water spray in the base of the air-suction pipe.

The condenser results are in no degree due to air-pump capacity, except where special mention is made of the fact. At all, except very low powers, the original single air-pump was capable of giving as high a vacuum efficiency as the three new pumps at their maximum capacity, and that one pump of the latter, working at a capacity of 0·7 of a cubic foot per pound of steam condensed, was practically as good as all three pumps at their maximum speed.

Symbols and Definitions.—The following are the symbols used in the tables and diagrams:—

- S = Total condensing surface in square feet, reckoning the external tube-surface between the tube-plate.
- W = Pounds of steam condensed per hour as measured.
- W_H = Pounds of steam condensed per hour reduced to heat units, and $= W\left(\frac{\text{total heat of steam at release-pr.} - t_H}{1070}\right)$.

To reduce different L.P. cylinder-release pressures to one basis, the quantity of steam used is here given in heat units, and divided by a constant on the basis of a uniform release-pressure of 8 pounds per square inch absolute of saturated steam, and a uniform hot-well temperature of 100° Fahr.

- Q = Quantity of condensing water in pounds per hour, as measured.
- V_t = Vacuum in inches of mercury as recorded at condenser top.
- V_b = Vacuum in inches of mercury as recorded at condenser bottom.
- V = V_t reduced to a barometer of 30 in. (NOTE.—When vacuum is referred to in the paper, it will, unless otherwise stated, always mean the vacuum at a 30 in. barometer.)
- V_c = Vacuum due to temperature t_c.
- t_i = Temperature (Fahr.) of condensing water at inlet to condenser.
- t_o = Temperature (Fahr.) of condensing water at outlet from condenser.
- t_v = Temperature (Fahr.) corresponding to vacuum V.
- t_c = Temperature of condenser at top, where exhaust steam enters.
- t_a = Temperature of condenser at bottom, at air-pump suction.
- t_H = Temperature of hot-well (feed water).
- a = Internal sectional area of one tube (square inches), minus core section, if any.
- s = External surface of one tube-element (square inches).

At the beginning of these experiments the engines were arranged for quadruple expansion, and as such they were retained throughout. The cylinders were 7 in., $10\frac{1}{2}$ in., $15\frac{1}{2}$ in., and 23 in. in diameter by 18 in. stroke. The same boilers also supplied steam throughout, so that the conditions for the different condensers were as constant as possible. The steam was superheated to an average of some 50° Fahr., as ascertained by a thermometer on the high pressure cylinder steam-chest. The maximum steam pressure was 210 lb. per square inch. There was little or no appearance of water at any of the piston or valve-rod stuffing-boxes.

The following method was adopted:—

For a given condenser the engines were adjusted for any required rate of condensation $\left(\frac{W}{S}\right)$. Then a series of trials—generally five—were made at this rate with different quantities of condensing water up to the maximum available. Great care was taken that the intervals between trials were of sufficient duration to permit of the new conditions attaining stability in all cases. For each rate of condensation $\left(\frac{W}{S}\right)$ a separate series of trials were made with varying quantities of condensing water $\left(\frac{Q}{W}\right)$. The condensed steam and the condensing water were both carefully measured by the calibrated appliances attached to the engine-testing plant.

The condensing water was obtained direct from the city mains, and the inlet temperature ranged from about 40° to 65°.

Several series of trials were made with a falling vacuum, as against a rising vacuum. It was found that, provided a sufficient interval elapsed between any two consecutive trials, there was no sensible difference in result as between falling and rising vacuum conditions.

The possibilities of air-leakage in these trials were considerable. The chief sources

were common to all the condensers—viz., the piston and valve-rod stuffing-boxes of the engine cylinders. The effect of these was noticeable at low rates of condensation, when not only the L.P., but the second I.P. cylinder and its valve-rods were generally working below the atmospheric pressure.

No series of trials was therefore entered upon until the value of the ratio $\frac{V}{V_c}$ was such as to indicate that the leakage was normal, and under the control of the air-pump to a degree which will be seen later on.

Two vacuum gauges as well as a mercury column were used on each condenser, all having been calibrated from a standard instrument. The readings of the gauge at the condenser top (V) were not always in absolute accord with those of the gauge at the condenser bottom (V_b). As the vacuum at the condenser top may be expected to control that in the engine cylinder, this was taken as the true vacuum, and is so recorded in the diagrams. Care was taken that no such thing as "induced" reading on a gauge could occur, by fitting a curved projecting nozzle to the gauge-pipe inside the condenser, and turning it round in all directions and observing the effect while a trial was in progress. In no case was the slightest induced effect observed.

The results are given in detail in tables.* The gist of them, however, will appear in the diagrams to be presently referred to.

Broadly speaking, the feature in these results is the considerable difference in efficiency between the two types of condensers when both are worked under the same conditions. For instance, taking a vacuum of 28 in., this may be attained in the old type at a water expenditure of forty-three times the feed water, while the new type, No. 2, requires only twenty-four times the feed for the same inlet temperature. Further, under these conditions the old type was condensing at the rate of about 10 lbs. per square foot, while the rate in the case of the new type was some 20 lb. per square foot.

There are several possible criteria of efficiency in a condenser, according to the point of view. In this connection the factors directly involved are the following:—
Steam condensed per square foot of surface $\left(\frac{W}{S}\right)$; water required per pound of steam $\left(\frac{Q}{W}\right)$; vacuum attained; hotwell temperature; power expended in producing the vacuum (*i.e.*, on circulating and air pumps); and size, weight, and first cost of condenser. The writer takes it that that condenser will be the most efficient which, with given water inlet temperature, air leakage, and air-pump capacity, maintains a given vacuum with the smallest condensing surface per pound of steam condensed, the smallest quantity of condensing water per pound of steam condensed, the smallest relative power expended in driving the circulating and air-pumps, the highest hot-well temperature, and the smallest weight and first cost in relation to the steam condensed. Another way of putting it would be, that that condenser is the most efficient which, all other things being equal as enumerated above, maintains the highest vacuum.

Old Type of Condenser.—The results are laid down in part of Fig. 13 for a condensing water-inlet temperature of 50°. It will be noticed there are four curves connecting vacuum and $\frac{Q}{W}$, a separate curve for each value of $\frac{W}{S}$. This is characteristic of all results the writer has yet met with from the old type of condenser. It means that when the rate of condensation $\left(\frac{W}{S}\right)$ is increased, other things being equal, the quantity of water per pound of steam $\left(\frac{Q}{W}\right)$ to maintain a given vacuum must also be increased. This is obviously due to a falling off in surface efficiency as the condensation rate is increased. Fig. 15 shows the outlet temperature (t_o) in relation to the vacuum temperature (t_v) for both types. It will be seen that for the old type the spots representing t_o are very scattered. This is due to the fact that t_o has a different value for each value of $\frac{W}{S}$ at a given vacuum. Further experiments were made with higher speeds of condensing water, and also with cores in the tubes. Although the results indicated a distinct improvement, they were still much inferior in surface efficiency to those obtained with the new condenser, and the thermal efficiency was, of course, unaltered.

New Type of Condenser.—The results from No. 2 of this type are first shown in Fig. 14. In this case one curve suffices to relate vacuum with $\frac{Q}{W}$ at all condensation rates within the trial limits—*i.e.*, up to $\frac{W}{S} = 20$. There is a certain amount of irregularity amongst the observation spots, but no general or regular deviation for any one rate

* Printed in the original proceedings.

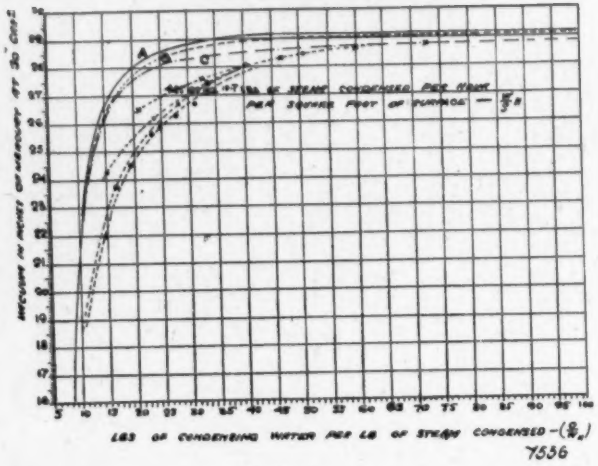


DIAGRAM SHEWING RELATIVE PERFORMANCE OF :-
ALL CURVES FOR INLET TEMPERATURE = 70°
COMPARE OLD TYPE CURVES WITH CURVE C
LBS OF CONDENSING WATER PER LB OF STEAM CONDENSED -(W/S)
7556

FIG. 13.

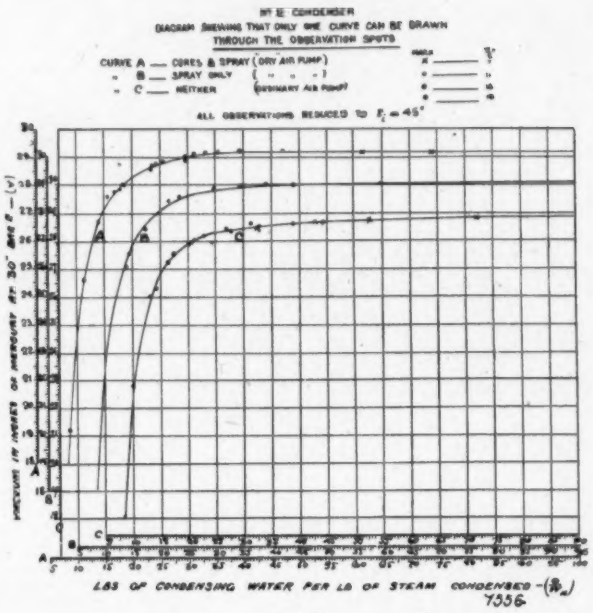


DIAGRAM SHEWING THAT ONLY ONE CURVE CAN BE DRAWN
THROUGH THE OBSERVATION SPOTS
CURVE A — CORES & SPRAY (DRY AIR PUMP)
ALL OBSERVATIONS REDUCED TO $F_t = 45°$
LBS OF CONDENSING WATER PER LB OF STEAM CONDENSED -(W/S)
7556

FIG. 14.

of condensation, and it is not possible to draw anything but one curve through them. This single curve is characteristic of this type of condenser. It always gives whatever may be the proportions of the condenser as regards surface-section ratio, or the conditions of working. The size of condenser has no effect (up to a value of at least $\frac{W}{S} = 37$, at which No. 3 condenser has been worked) on the quantity of water required for a given vacuum. Whatever may be the condensation-rate, the outlet temperature is constant if the vacuum is kept constant by variation in quantity of condensing water, the inlet temperature being of course, assumed constant. In other words, surface-efficiency $\frac{t_o}{t_v}$ remains unaltered at constant vacuum.

Fig. 15 shows how closely t_o follows t_v under certain conditions there specified, and that t_o does not fluctuate up or down as $\frac{W}{S}$ is altered, as is the case with the old type, any fluctuation in t_o being entirely due to variation in t_i. Further, it will be noted from the same diagram that t_o for the new type is much higher

on the whole than for the old type, and that under the best conditions it closely corresponds with t_v, sometimes rising slightly above it, according to the inlet temperature, which varied from 46° to 65°.

Fig. 14 shows curves for three different conditions of working; first, with open tubes and ordinary air-pumps (curve C); second, with open tubes and the dry air-pump system, with cold spray in air-pump suction-pipe (curve B); and third, with cores in the tubes conjoined with the dry air-pump system and spray, (curve A). The three curves are drawn in this diagram to separate scales some distance apart from each other, in order that the observation spots belonging to each curve may be clearly seen.

In Fig. 13 the same curves are drawn in their true relative positions to the same scales, and, to save confusion, the spots for No. 2 condenser are omitted.

Surface-Efficiency. — Surface-efficiency is at the root of all efficiency in a surface-condenser. That condenser is the most efficient in which each square foot of surface transfers in given time and conditions, as to water supply, &c., from the steam to the water, the largest number of heat units. This will, moreover, be the condenser which will not only register the highest vacuum, but will maintain it at the least cost in condensing water, and with the smallest surface and cubical capacity per pound of steam condensed. It will also, in given conditions, be the one to yield the highest hot-well temperature. Now, in order that a surface may thus act, it is necessary that the steam should have free access to, and should pass over, sufficient surface on the one side, and that all the condensing water should come into direct and efficient contact with the surface on the other side. This clearly cannot be the case if on the steam side practically the whole surface is continually subjected to showers from the water of condensation, or if the steam can short-circuit any material amount of the surface; nor can it be the case on the water side if the condensing water flows through the tubes in unbroken cylindrical streams, the peripheries of which streams alone come into actual contact with the tube surface, and a greater or less proportion of water-core passes through without efficient contact. Hence the augmented efficiency of the surface as a whole, due to the early interception and removal of the feed-water, the provision for promoting steam circulation, and the adoption of a suitable ratio between the surface and the water-carrying section of each tube element, by the introduction of a solid displacing core in the tubes or otherwise, all as shown in Figs. 13 and 15. The effect of the use of cores, as against open tubes, on economy in vacuum production will be dealt with later on. The cores used on these trials were triangular laths of hard wood, rough from the saw. They were about 2 in. longer than the tubes, and were simply inserted in the tubes without any fastening whatever. The sketch below shows a section of tube and core in place.

The index of relative surface-efficiency is the ratio $\frac{t_e}{t_v}$ in relation to $t_i\ t_o - t_i$ = heat-units absorbed per pound of condensing water. The greater this quantity, the less the condensing water required per pound of the steam condensed. Hence, economy of condensing water is one very important result of enhanced surface-efficiency. Economy of water is important from several points of view. First, as in the case of land installations, water may itself have to be purchased. Second, it has to be pumped through the condenser; and any saving in water means, other things being equal, power economy in vacuum production. Third, water may have to be cooled for repeated use, and in this case surface-efficiency of condenser has a double effect. Not only is there less water to be pumped, but owing to its higher outlet temperature there will be a greater mean difference between the temperature of the water to be cooled and the air which cools it; and hence cooling towers will be more efficient, and may therefore be of smaller size for given power.

Another important result of enhanced surface-efficiency is, of course, economy of condensing surface. Owing to steam space being dispensed with in the new type, a given surface is contained in less capacity of condenser-shell. These two features conduce to economy of weight and capacity. From the point of view, therefore, of weight and space occupied, the new type of condenser has important advantages, which would seem to render it peculiarly adapted for use on board ship, and specially so for all classes of war vessels, in which both weight and space are of supreme importance. In the case of marine condensers, economy of condensing water is of itself of secondary importance; but economy of pumping power, of weight and space occupied, degree of vacuum maintained, and hot-well temperature, are all of great importance. Of all the condensers tested in these trials, the proportions of No. 3 seemed best suited to marine conditions, inasmuch as this condenser, at the cost of some sacrifice in

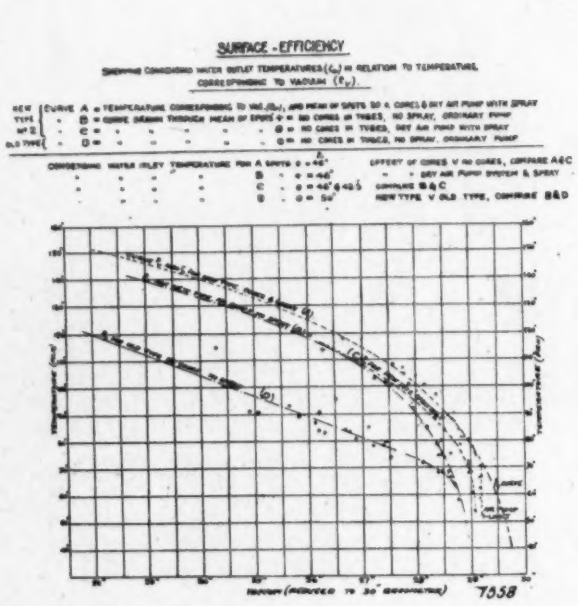


FIG. 15.

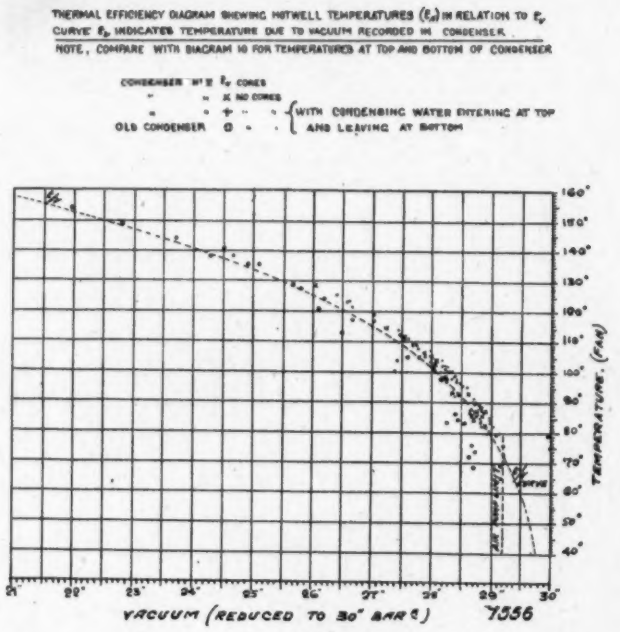

THERMAL EFFICIENCY DIAGRAM SHEWING HOTWELL TEMPERATURES (t_w) IN RELATION TO t_v
CURVE t_v INDICATES TEMPERATURE DUE TO VACUUM RECORDED IN CONDENSER.
NOTE, COMPARE WITH DIAGRAM 10 FOR TEMPERATURES AT TOP AND BOTTOM OF CONDENSER
VACUUM (REDUCED TO 30" BAR.)
7356

FIG. 16.

condensing water, as compared with No. 2, maintains any vacuum up to the highest, with considerably less surface than is the case with No. 2, and very much less than in the case of the old type. In the following table is given a comparison of the sizes and performances of the three condensers under as nearly as possible similar conditions for a common vacuum of, say, 28 in.

Column 6 will also represent approximately the relative weights and costs for the same indicated horse power.

Under the conditions taken, the experimental engines use an average of 12 lb. of steam per indicated horse-power per hour, and this is the basis of column 6. Most marine engines, however, will probably require more than this, and assuming a consumption of 15 lb. of steam, the figures in column 6 become 0·456, 0·75, and 1·5 square feet per indicated horse-power respectively.

Even under these conditions it is to be noted that the old type is using a much greater total quantity of condensing water than either of the other condensers, and that its hot-well

Condenser.	1. Surface.	2. Capacity.	3. Steam Condensed per Square Foot per Hour.	4. Vacuum.	5. Condensing Water per 1 lb. of Steam. (Inlet = 56°.)	6. Surface per I.H.P. (Allowing 12 lb. of Steam per I.H.P. Hour.)	7. Relative Capacity per I.H.P. (No. 3, being = 1.)
	sq. ft.	cu. ft.	lb.	in.		sq. ft.	
No. 3	62	6	33	28	32	0·36	1
,, 2	100	9·6	20	28	24	0·6	1·63
Old type	170	18	10	28	43	1·2	3·6

temperature will be 94°, as against 106° for the others. If the old type is brought up to the level of No. 3 as regards condensing water per pound of steam, its allowance of surface per indicated horse-power must be raised to 2·8 in column 6 of the above table.

Thermal efficiency.—The dictates of heat economy prescribe that the water resulting from condensation shall not be cooled any further than is necessary for the production of a given vacuum. If, therefore, any required vacuum is obtained without the necessity of cooling the water unduly, this would, other things being equal, be an advantage. But as the writer interprets the results of these trials, the other things are not, and cannot be, equal. Not only is it possible to maintain a vacuum, which may, if required, be as high as 29 in. with an air-pump of not unusual capacity, with a hot-well temperature of 3° to 5° above that due to the vacuum, but to do this with less expenditure of condensing water and less condensing surface than would be the case were the conditions such as to yield a hot-well lower in temperature. In other words, the higher hot-well temperatures and the smaller amount of condensing water and surface are both due, the former entirely and the latter partially, to the same cause—viz., the compartment-drainage of the condenser. The advanced thermal efficiency of the new type as compared with the old type, shown in Fig. 16, is undoubtedly due to the measures adopted in the former for removing the water of condensation as soon as possible after it is thrown down from the steam, thus preventing its trickling over the comparatively cold tubes towards the bottom of the condenser. At all except very high rates of condensation, or with very small quantities of condensing water per pound of steam, the greater proportion of the condensing work is done by the surface situated in the uppermost compartment. The great mass of the feed-water is therefore withdrawn from the condenser at a temperature sensibly equal to that obtaining in the top compartment of the condenser, and without passing over the cooler compartments lower down, and specially escaping the lowest compartment of all, which is thus reserved as an efficient air-cooling section.

From Fig. 16 it will be noticed that the hot-well temperatures of the whole type are from 10 to 15° lower than those for corresponding conditions in the new type for all degrees of vacua exceeding 26 in., and that the presence of cores in the tubes has very little, if any, effect upon the hot-well temperature.

Experiments were made with the condensing water entering at the top and leaving at at the bottom of the condenser. These results* indicate that the water ought to enter at the bottom and leave at the top.

The absolute pressure in these condensers is practically uniform throughout the interior. But the temperature is not uniform throughout. It is always higher at the top than at the bottom. The absolute pressure, therefore—*i.e.*, the vacuum—must be a compromise between that due to the top and that due to bottom temperatures. As a matter of fact, in air-tight systems the vacuum recorded is generally somewhat higher than that corresponding to the top temperature, but is not so high as the bottom temperature would indicate, especially at high vacua. Hence, t_v, which corresponds to the vacuum recorded, is lower than the temperature obtaining at the condenser top (t_c). But t_o and t_h are both a function of t_c (because the condensing water emerges finally from the *top*, and the feed-water is the result of condensation mainly in the top compartment of the new type), and hence the possibility of t_o and t_h exceeding t_v in value, as we find they actually do in certain circumstances. The hot-well temperatures (t_h) for the new type correspond very closely with the condenser top temperatures (t_c), and for the old type with the condenser bottom temperatures (t_a).

Economy in Vacuum Production.—Conditions are conceivable in which a given vacuum might be too dearly purchased. Leaving out of account for the moment all question of the first cost or weight of the vacuum-producing appliances, including condenser and pumps, as well as any commercial value attached to the condensing water, we have on one side of the account the power expended in maintaining the

* Given in full in the original paper.

vacuum, and on the other side the power realised from it. Obviously, if a given vacuum should cost more in power for its attainment than it returns in the shape of power due to it in the engines, it would be bad policy to work at such a vacuum. On the above basis, the power-cost of a vacuum will comprise the power required to drive the air and circulating pumps. The power absorbed by the air-pump will clearly depend upon its size and speed, but, so far as degree of vacuum is concerned, the power seems to be practically independent of the vacuum, at least for the "Edwards" type of pump, and for the vacua ranging between 26 in. and 29 in.

As regards the power absorbed by the circulating-pump, this will, of course, depend upon several factors, according to the circumstances of each individual case; but so far as the essential circumstance is concerned—viz., the production of different degrees of vacua in a given condenser—the power will depend on two factors only—the quantity of condensing water, and the head or pressure against which it is propelled through the condenser. The power-cost of circulating the condensing water will therefore be proportional to the product of the pounds of water circulated per minute, and the resistance, expressed in feet of head, against which it is circulated. Due allowances being made for the efficiencies of the pump and the engine which drives it, the gross power expended in circulating the water for different vacua on this basis is shown in Fig. 17, which refers to an inlet temperature of 50°. It will be noticed from this diagram that the use of tube-cores raises the highest attainable vacuum, in the conditions obtaining, by nearly ½ in., but at a greatly enhanced cost in pumping power.

The most economical vacuum, in its widest sense, at which to work in any given case depends chiefly on the engines, but it also depends, to a considerable extent, on the condenser. In so far as it depends upon the steam consumption in the main engines, it is beyond the scope and purpose of this paper. In so far as it depends upon the condenser, it falls to be dealt with here.

In the region of extremely high vacua, increments of vacuum are attained at increasing power-cost in circulating the condensing water, and it therefore becomes a matter of importance to ascertain, for given circumstances, the limit of vacuum beyond which the vacuum cost exceeds the vacuum return. Inasmuch as this return depends on the engines, it follows that their proportions and type must be factors involved in the economics of vacuum-production.

Fig. 18 shows the higher limits of vacuum beyond which the power expended in producing the vacuum exceeds that realised from it under certain specified conditions, which are fully given on the diagram. Curves are plotted for two rates of condensation only—7 lb. and 15 lb. per square foot per hour. The lower curves refer to the engines which were used in the trials, and the upper curves to a 1,000-kilowatt steam turbine, the power of which is reduced to bring it into comparison with the power scale of the reciprocating engines. The air-pump power is not included in these curves, for the reason already given.

The speed of circulating water in the tubes varied in these trials from 1¼ ft. to 4½ ft. per second with no cores, and from 1¾ ft. to 6½ ft. per second with cores, the corresponding maximum resistances being those due to heads of 10 ft. and 32 ft. respectively.

It would appear from this that, so far as economy in vacuum-production is concerned, the head against which the condensing water is circulated may be considerably higher than is often at the present time considered desirable or admissible. The most economical vacuum at which to work, from the point of view of steam economy, will, in the case of reciprocating engines, always be lower than the limits referred to in Fig. 18; how much lower depending almost entirely on the engines utilising the vacuum. For turbines, on the other hand, it is generally understood that the vacuum associated with maximum steam economy is always coincident with the highest attainable vacuum.

Surface-Section Ratio : $= \left(\frac{s}{a}\right)$. The numerator of this ratio indicates proportional heat-absorbing capacity, and the denominator proportional condensing water-carrying capacity; and it might therefore be expected to have a determining influence upon the efficiency of condensers on the water side. As a result of plotting, for several values of $\left(\frac{Q}{W_H}\right)$, the vacuum realised at the various values of surface section ratio comprised within the scope of these trials, it was seen that there is a gradual rise in vacuum as surface-section increases in value. The trials of condensers 1, 2, and 3 indicate that in this type of condenser surface-efficiency is independent of rate of condensation—at least, up to 37 lb. per square foot of surface per hour—but

that it is materially dependent upon the value of the surface-section ratio. The exact and full significance of this ratio, and especially its influence on condenser size, can, however, be determined only by further experiments on condensers with different proportions, and with various effective tube-lengths.

Air-Pump Capacity.—As already mentioned, a very large number of trials were made with the pump capacities, and arrangements and conditions varied in every possible way. These trials yielded results all pointing to the same conclusions, and a typical series is given in the original paper which show, first, that when the system is fairly air-tight, a pump-capacity of 0·7 of a cubic foot per pound of steam condensed is as good as anything larger. But, second, when the air-leakage exceeds a certain amount, larger pump capacities are necessary for the maintenance of the vacuum previously existing. Third, that there is no apparent advantage in working ordinary pumps on the compound principle.

It is, perhaps, necessary to point out that in these trials reductions in rates of condensation—*i.e.*, in power—were obtained by increased expansions, or by lower initial steam pressures, the

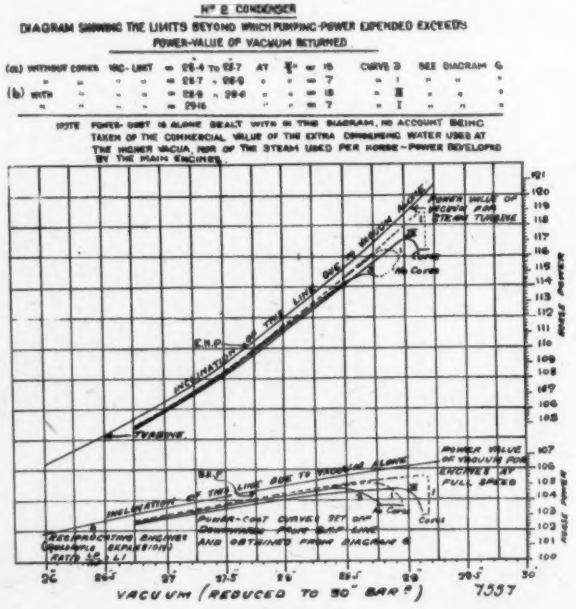

N° 2 CONDENSER
DIAGRAM SHOWING THE LIMITS BEYOND WHICH PUMPING-POWER EXPENDED EXCEEDS POWER-VALUE OF VACUUM RETURNED
NOTE POWER-COST IS ALONE DEALT WITH IN THIS DIAGRAM, NO ACCOUNT BEING TAKEN OF THE COMMERCIAL VALUE OF THE EXTRA CONDENSING WATER USED AT THE HIGHER VACUA, NOR OF THE STEAM USED PER HORSE-POWER DEVELOPED BY THE MAIN ENGINES.
I.H.P.
TURBINE.
B.H.P.
No Coils
VACUUM (REDUCED TO 30" BAR°)
7537

FIG. 17.

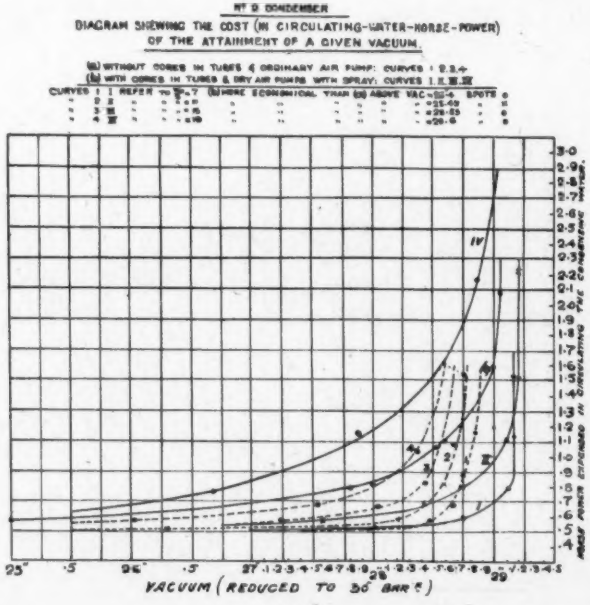

N° 2 CONDENSER
DIAGRAM SHEWING THE COST (IN CIRCULATING-WATER-HORSE-POWER) OF THE ATTAINMENT OF A GIVEN VACUUM.
VACUUM (REDUCED TO 30" BAR°)

FIG. 18.

revolutions being retained constant throughout. The result was that, at the lower powers, the receivers of the last two cylinders were working at pressures below the atmosphere. This condition of matters was always associated with a marked increase in the quantity of air discharged by the air-pumps, and a tendency for the vacuum to fall, due, no doubt, to increased air-leakage at the stuffing-boxes of the receivers and cylinders. Although these stuffing-boxes were packed with special packing and were kept in good condition, it was quite impossible entirely to prevent air-leakage occurring in this way. At full power, when the L.P. receiver-pressure will be slightly above the atmosphere, 0·7 of a cubic foot capacity maintains a given vaccum; at quarter power the same vacuum needs an expenditure of 6·5 cubic feet to maintain it. It was always in these trials found that at high powers the vacuum was determined by the condenser temperature, while at lower powers it was determined in an increasing degree by the air pressure in the condenser; and at the lowest power of all it had little relation to the temperature, but was determined solely by the amount of air-leakage and the capacity of the air-pump to overcome it. All this for extremely high vacua—say, above 28 in. At vacua below that figure the effects of even considerable air-leakage are not so noticeable.

The effect of the "dry" air-pump system in raising the vacuum obtainable from a given expenditure of condensing water will be seen from Fig. 13 to be something considerable, but, of course, at the cost of increased pump capacity in relation to the steam condensed.

From the foregoing results the following conclusions are drawn:—

1. It is conducive to efficiency in a surface condenser that the water resulting from condensation should be intercepted and removed from the condenser as soon as possible after it is formed.

2. It is conducive to efficiency that the condenser capacity should be a minimum consistent with the accommodation of the necessary surface, and that the design should be such as to secure a pervading and uniform flow of vapour throughout the condenser section, thus utilising the whole of the condensing surface provided, as well as obviating stagnant recesses in which air might be retained.

3. It is conducive to efficiency that the condensing water should travel at a fairly high speed through the tubes, and that it should enter at the bottom and leave at the top of the condenser.

4. With suitable condenser design and proportions, the temperature of the condensing water at the discharge point may be equal to, or slightly higher than, the temperature due to the vacuum. This holds true for vacua up to slightly over 29 in.

5. With suitable condenser design and proportions, the temperature of the hot-well may be from 3° to 5° higher than the temperature due to the vacuum. This holds true for vacua up to slightly over 29 in.

6. With suitable condenser arrangements and a reasonably air-tight system, there is nothing gained in efficiency by the use of air-pumps exceeding in capacity 0·7 of a cubic foot per pound of steam condensed, up to a limit of close upon 29-in. vacuum. For vacua exceeding this limit, or for cases in which air-leakage is considerable, the air-pump capacity must be increased, or else the vacuum-efficiency will fall.

7. With suitable condenser design and proportions, and in conjunction with "dry" air pumps, a condensation rate of at least 20 lb. steam per square foot of surface per hour will be maintained in association with a vacuum of 28½ ins., and a quantity of condensing water equal to twenty-four times the feed water, at an inlet temperature of 50°.

8. With suitable condenser design and proportions, and in conjunction with "dry" air pumps, a condensation rate of at least 36 lb. of steam per square foot of surface per hour will be maintained in association with a vacuum of 28½ ins., and a quantity of condensing water equal to twenty-eight times the feed water, at an inlet temperature of 50°.

The most economical vacuum, in its widest sense, will obviously be that vacuum with which is associated the minimum steam consumption per horse power developed. Whatever may be the value of this particular vacuum in any given degree, it is clear that it cannot possibly exceed that degree of vacuum beyond which the pump power absorbed in increasing the vacuum exceeds the power-return in the main engines due to that increase. This much, at any rate, is clear, without any reference whatever to the consumption of steam in the engines utilising the vacuum.

It will be noted that when the condenser is used in connection with a steam turbine, the limit in economical vacuum-production is practically identical with the highest attainable vacuum, and that when used in conjunction with reciprocating quadruple-expansion of the stated proportions, the limit is slightly less than the maximum vacuum; but the difference between the two cases is not very striking.

The Education of Engineers.

In the month of November, 1903, the Council of the Institution of Civil Engineers resolved to appoint a special committee whose duty it should be "to consider and report . . . as to the best methods of training for all classes of engineers, including both scholastic and subsequent technical education, it being an instruction to this committee that the principle shall be maintained that the education of an engineer must include both practical experience and scientific training." Other engineering societies were invited to nominate representatives to serve on this committee, and in February, 1904, the constitution of the committee was completed as follows: Sir William H. White, K.C.B. (Chairman); Sir John Wolfe Barry, K.C.B.; Sir Alex. B. W. Kennedy; J. H. Wicksteed, Esq.; Alex. Gracie, Esq.; Sir Edward Carbutt, Bart.; R. Kaye Gray, Esq.; Harry E. Jones, Esq.; Prof. Arch. Barr; Prof. Henry Louis; Prof. R. L. Weighton; J. H. T. Tudsbery, Esq. (Secretary); and J. G. Henderson, Esq. (Assist.-Secretary). Sir Edward Carbutt died in October, 1905, and his place on the committee was taken by Mr. A. T. Tannett-Walker, as representative of the Iron and Steel Institute.

The report of this committee has just been published, and it deserves the careful attention of all interested in the profession of engineering. In recent years there has been much spoken and printed regarding the education of engineers, but these communications are almost entirely the expression of opinion of individuals, and cannot be accepted as representative of all classes of engineers. Not only so, but the opinions expressed are in many cases conflicting. The real value, therefore, of the present report is that it contains the unanimous recommendations of a thoroughly representative body. The individual members of the committee are well qualified to form opinions on the subject of their inquiry, but, in addition, each is a representative of an important engineering society or institution, and by reference to that society has been able to bring before his fellow-members of committee the general opinion of his branch of the profession. The method of inquiry pursued by the committee also helped materially to secure valuable results. Series of questions and suggestions were drawn up by the committee, and copies sent to representative men, in all parts of the country, having knowledge and experience of the matters in question, and in the replies to these inquiries the committee collected "a great body of opinion from representative engineers in active practice, professors and teachers in technical colleges and universities, and others whose advice has been of value in reaching a decision on matters referred to the committee." The questions and suggestions circulated in this manner are printed in appendices to the report, and opposite each is given a summary of the replies received.

School Education.—The first section of the committee's inquiry deals with the preparatory education of engineers in secondary schools, with special reference to suitable training in mathematics, elementary science, modern languages, and handicrafts. The schedule of questions prepared under this section was issued to 120 representatives of teachers in engineering colleges, head-masters in secondary schools, and engineers not engaged in teaching, and replies were received from 80 per cent. of those whose opinions were invited. The summary of replies shows a striking unanimity of opinion on the points set out by the committee, and indicates clearly the line to be followed by the committee in its recommendations. These may be briefly summarised as follows: A boy who intends to be an engineer should receive a sound general education at school without any attempt to specialise; he should remain at school until he is about seventeen years of age; his curriculum of study should include advanced teaching of history and geography, sound instruction and practice in essay-writing and précis-writing, and at least an introduction to English literature; Greek should not be required; an elementary knowledge of Latin is desirable, but in the later years of school-life the study of Latin should be discontinued in favour of modern languages, especially French and German, which should be taught colloquially, or in such a way as to give the pupils a practical knowledge of each language, sufficient to enable them to study its literature and to converse

in it with some degree of facility. In mathematics, the geometrical side should be specially cultivated; boys on leaving school should be familiar with the use of logarithms and the elements of trigonometry. In practical arithmetic pupils should be instructed in the use of contracted methods, and encouraged to express results with only such a degree of numerical precision as is consistent with the known degree of certainty of the data on which they are based; and operations in mental arithmetic should be encouraged. The study of science at school should be confined to an elementary knowledge of physics and chemistry, and not extended to the detailed study of any one branch of science. Special attention should be given to drawing — freehand, geometrical, and curve drawing; and instruction should be given in practical mensuration. Handicraft work should not be required as a school exercise.

These recommendations appear to us to be very sound. They are especially welcome to us in that they are in exact agreement with an opinion we expressed one month before this committee was appointed, when we had to enter a strong protest against the introduction of specialised instruction into the early curriculum of the engineer. On that occasion (see ENGINEERING REVIEW, vol. ix., October, 1903, p. 335) we wrote :—

> "The old notion of school life, and even of university life—and one, be it remembered, which produced the great engineers of the past, who had no technical training at all in their young days—was that that was a period which ought to be devoted to the training and development of the mind, not to cramming it with facts on special subjects, but using studies as a means of training the scholar's mind to such a state that when he leaves school he will be able to use his intelligence, to think for himself, and rely upon himself: to observe things and remember them afterwards. . . . If our schools turn out trained and cultured minds, we shall not want for trained engineers."

It is because the recommendations of the committee will, if carried out, maintain this view of the function of schools and school education, that we welcome them so heartily.

Limitations of space will not allow us to discuss these recommendations in detail, but one or two remarks may be made upon them. We attach great importance to the suggestion of instruction and practice in essay-writing, as it is unfortunately true that engineers, as a class, do not write English well. The writing of essays is important not only as a training in style and easy expression, but also because it leads to precision in thinking, which is all-important to students of science. For the same reasons the study of languages is very desirable, and while a knowledge of French and German is of great practical value, the study of Latin is also to be recommended as affording perhaps the best training in exact expression of thought. For rapidity in thinking nothing provides a better training than mental arithmetic, and we earnestly hope to see this recommendation of the committee adopted in all our schools, elementary and secondary.

Later Education, Theoretical and Practical.—The later section of the committee's inquiry deals with the training of the engineer after he leaves school—that is to say, preliminary training in offices, workshops, factories, or on works, and training in colleges and higher technical schools. In this inquiry each member of the committee consulted the authorities of the institution which he represented as to the names of gentlemen whose opinions should be invited, and in the end 676 schedules containing inquiries drafted by the committee were sent out. The number of replies received was 267, or about 40 per cent. of those invited to give an opinion. No doubt many of the gentlemen who received schedules, and who were, without exception, actively engaged in professional work, had many demands upon their time, but we cannot help thinking that in such an important matter, which so closely concerns the interests of the profession, a larger response to the invitation might have been expected. The replies received, however, are representative of all classes of engineers, and the committee has been able to arrive at definite opinions.

The general scheme recommended is that, on leaving school, when he is about seventeen years of age, the boy should have an introductory workshop course for not less than one year nor more than two years, working the regular hours like an ordinary apprentice and receiving wages. Preferably this practical course should be taken before college training is commenced, but, at the latest, it should follow the period of college training which is common to all branches of engineering. The question of attendance at evening classes during this workshop course must depend upon the physique of the individual, and while those who are fit for it may properly be encouraged to add to their knowledge in this manner, nothing should be done in the way of evening study which would impose undue strain upon the boys. After this introductory workshop course, the boy should have a college course

for the minimum period of three years, and, if possible, for four years. The first year of the three years' course, and perhaps the first two years, if a four years' course be taken, should be devoted to a common course of study for all classes of engineers. In the later years more specialised studies may be undertaken. The practical training recommended for those who have reached the age of specialisation, is a period of two or three years for those who have already taken the "introductory workshop course," and three years—except in cases of exceptional ability—for those who have gone straight from school to college. The committee recommend that in the granting of degrees and diplomas importance should be attached to laboratory and experimental work, and that in the higher technical institutions the facilities for post-graduate work should be increased.

The scheme here laid down is not, of course, intended to be rigidly followed. Circumstances will differ in different places, and variations on this scheme may be found advisable, but as a general plan for the combination of theoretical and practical instruction, it appears to be well-devised and quite practicable. It will be noticed—and to us this is a meritorious feature of the scheme—that the age of specialisation is postponed even beyond the stage at which the boy leaves school. His early days at college will be spent in the study of subjects common to all branches of engineering, and when he has mastered these—and not till then—he may go on to special subjects. That this is a wise recommendation we have no doubt whatever. The two years' study of a special branch is sufficient to give the young engineer sound instruction in the principles of his subject, and when he, on leaving college, goes on to take his specialised practical training for a further two years, he is at the outset able to understand the work he is called upon to do, and at the end should be a thoroughly competent engineer.

We trust that this report may not be put aside and forgotten by those to whom it is primarily addressed. The committee has done its work well; it now remains for others to act upon it. The committee expresses the opinion that "the improvement of engineering education depends greatly on the attitude of employers towards the suggestions foreshadowed" in their memorandum, and we note that 70 per cent. of the replies received from engineers in practice agree with this opinion. We hope, therefore, that employers will assist the committee by giving trained young men "opportunities of using their knowledge in actual work."

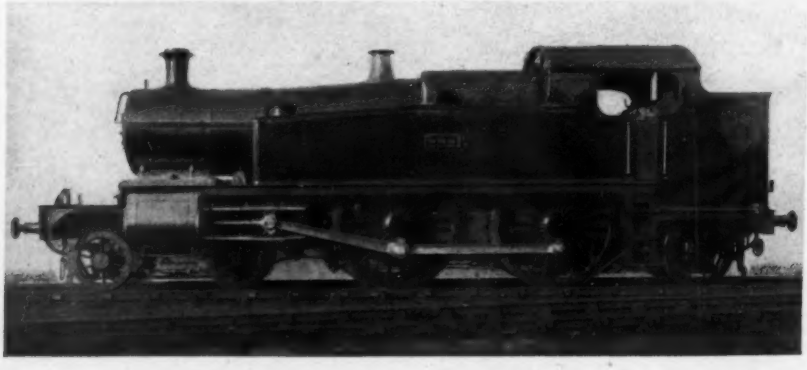
Locomotive and Railway Engineering.

By CHAS. S. LAKE.

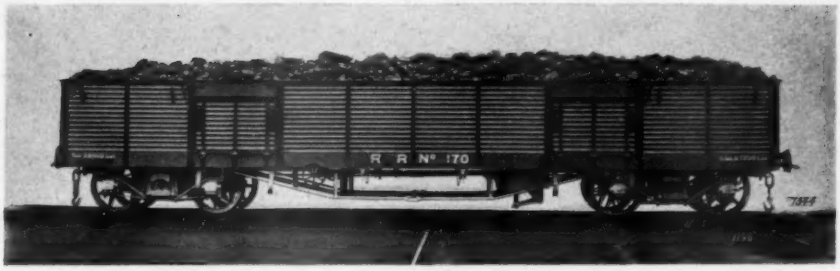
New Passenger Tank Engines. Great Western Railway.—The locomotive shown in the accompanying illustration is one of a new series recently completed at Swindon Works, Great Western Railway. It, with others of the same class, has been designed for working passenger trains at high average speeds, the distance limit being mostly governed by the question of fuel supply, as the engine is fitted with water pick-up apparatus suitable for both direction running, the scoop being of the balanced type and very easily operated.

The design is practically the same as that of the "County" class 4-4-0 type, express locomotives, designed by Mr. G. J. Churchward for working long distance express passenger traffic on the Great Western main line. The cylinders, motion and wheels are of the same dimensions and pattern as in those engines, the main difference between the two classes being that whereas the one is accompanied by a six-wheeled tender, the other has side tanks and a rear bunker supported upon a two-wheeled radial truck. Piston valves, actuated by Stephenson link motion, are used for distributing steam to the cylinders, which latter are placed outside the frames and drive the leading pair of coupled wheels.

The boiler is of the coned pattern now adopted as standard for all classes of locomotives on the Great Western Railway. It is not provided with a dome, steam being taken at a point near the front end of the fire-box by means of a main pipe with two branches, each having an upturned mouth, one on either side of the firebox casing just underneath the outer shell, the regulator being in the smoke-box. The latter is of the extended type resting upon a saddle cast in two halves, each half being in one piece with a cylinder and piston valve chest. This arrangement makes a very simple and straightforward job, and by its use the processes of machining and repairing are greatly facilitated. The connecting rod big end is of the solid bushed type; the end of the crank pin has a fine thread cut on it, and the cap is screwed on and afterwards secured by a threaded taper pin through it. The large size (for a tank engine) of the coupled wheels—6 ft. 8½ in.—which is the diameter now employed for all passenger locomotives intended for fast service on the Great Western Railway, will render the new engines distinct from any others of the "tank" order in this and probably other countries. Prior to the introduction of this series the largest driving wheels employed for locomotives of this description were to be found on the London, Tilbury and Southend Railway. In this case the diameter is 6 ft. 6 in. and the same arrangement of cylinders and wheels is employed.



NEW PASSENGER TANK ENGINE, GREAT WESTERN RAILWAY.



30-TON BOGIE WAGON FOR THE RHODESIAN RAILWAYS.

The principal dimensions of the locomotive illustrated are as follows:

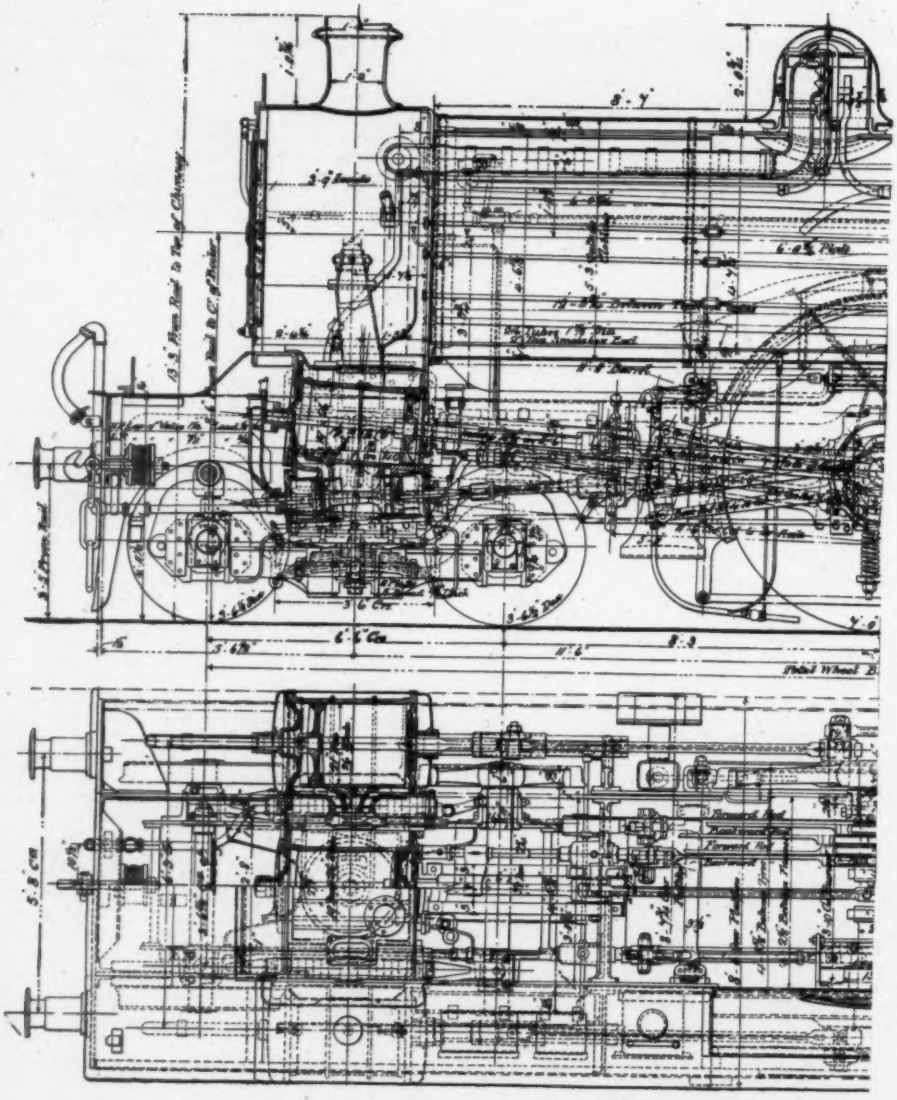
Cylinders	...	...	18 in. dia. by 30 in. stroke
Steam ports	...	...	31½ in. by 1¾ in.
Exhaust ,,	...	...	31½ in. by 4½ in.
Bogie wheels	...	...	3 ft. 2 ins. dia.
Coupled wheels	...	...	6 ft. 8½ in. dia.
Radial truck	...	...	3 ft. 8 in.
Boiler barrel, length	...	...	11 ft. dia.
,, ,, dia. outside	...		5 ft. ⅛ in. firebox end
,, ,, ,,	...		4 ft. 5⅛ in smokebox end
Number of tubes	,,	...	289
Dia. of tubes	...	...	1⅝ in.
Heating surface, tubes		...	1396·58 sq. ft.
,, ,, firebox		...	121·31 sq. ft.
,, ,, total		...	1517·89 ,,
Grate area ,,		...	20·35 sq. ft.
Steam pressure		...	195 lbs. per sq. in.
Firebox, outside		...	7 ft. by 5 ft. 3 in. to 4 ft.
,, inside		...	6 ft. 2⅞ in. by 4ft. 3½ in. to 3 ft. 2⅜ in.
,, height		...	6 ft. 7/16 in. and 5 ft. 7/16 in.

The bogie wheel base is 7 ft., coupled wheel base, 8 ft. 6 in., and total wheel base 32 ft. Length over buffers 41 ft. 4 in., tank capacity 2,000 gallons, tractive force 21·190 lbs.

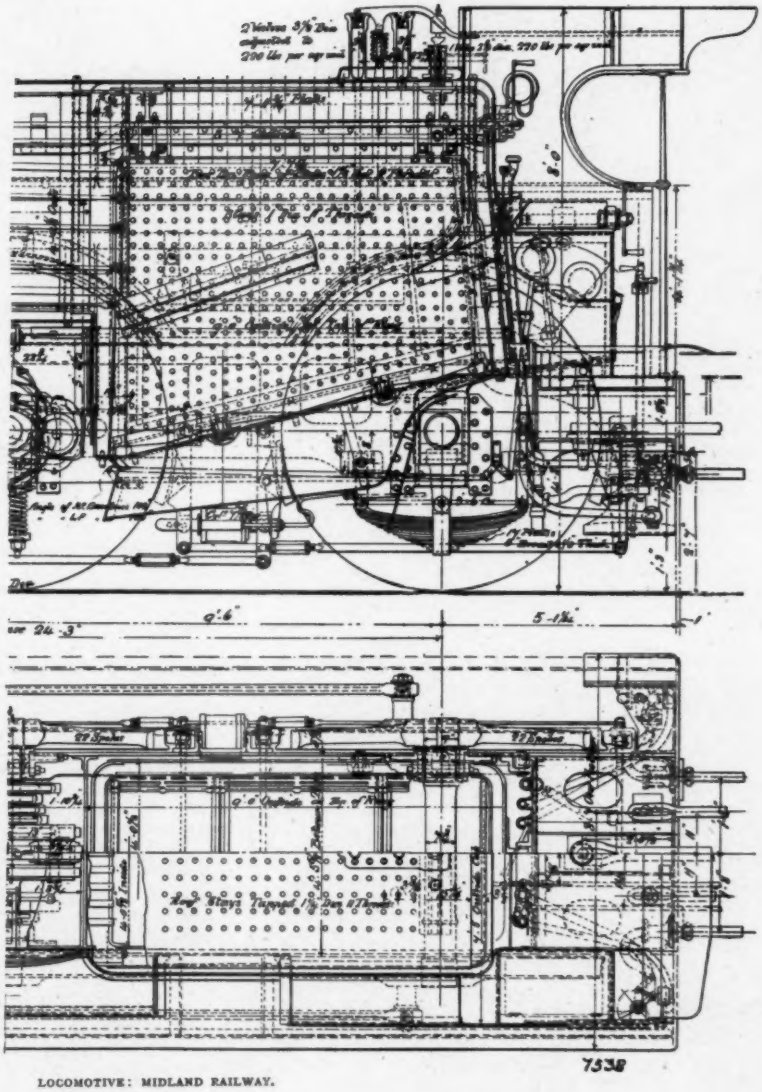
30-Ton Bogie Wagons, Rhodesia Railways.—The writer is indebted to Messrs. the Metropolitan Amalgamated Railway Carriage and Wagon Co., Ltd., for a photograph and particulars of one of a number of 30-ton all-steel high-sided bogie wagons built at their Lancaster works for the Rhodesia Railways. The wagons are mounted upon two four-wheeled bogie trucks, with framing of the diamond pattern. The wheels have a diameter on tread of 2 ft. 9½ in., and the wheelbase of each bogie is 5 ft. 6 in., the distance between centres being 26 ft. 8 in. The body portion is constructed of corrugated steel plates ¼ in. thick, with 3 in. by ¾ in. corrugations. The floor plates are of steel, 5/16 in. thick, and the underframe is built up of steel channels, 9 in. by 3 in. by 18½ in. The length over headstocks is 37 ft., and the width outside 7 ft. 9 in., the height at the sides and ends being 3 ft. 9 in. Two doors are provided on each side of the wagon; these are attached by three hinges at the bottom and fall outwards to open. The bogie-framing is built of bar steel with flanged steel bolsters and spring planks. The wheel centres are of wrought iron, hydraulically forged, the tyres and axles being of steel, and the axle-boxes adapted for oil lubrication.

The spiral bearing springs are graduated for varying loads and the wagons are fitted with the automatic vacuum brake, with the "Thomas" patent either-side brake in addition. The wagons are for traffic from the collieries in the Wankie and Gwanda districts of South Africa.

New Compound Locomotives—Midland Railway.—The photographic reproduction of the new Midland Railway compound locomotive, No. 1000, which appeared with last month's notes, is supplemented herewith by sectional elevation and plan drawings, which, as will be seen, is of the 4-4-0 type, with one high-pressure cylinder between the frames and two low-pressure outside, all three driving the first pair of coupled wheels. The middle high-pressure cylinder takes steam direct from the boiler at a pressure of 220 lbs. per square inch, and this steam exhausts into the chest common to the low-pressure cylinders. The steam regulator is of the gridiron type, with main and jockey valves as usual. There are three ports in the valve face of the regulator head, two of which communicate with the main steam pipe, and the third with an auxiliary pipe connected to the steam chest of the low-pressure cylinders. The arrangement is such that when the regulator is closed a port through the main valve superimposes on the port leading into the low-pressure auxiliary pipe, and this port and the bypass



3-CYLINDER COMPOUND EXPRESS



LOCOMOTIVE: MIDLAND RAILWAY.

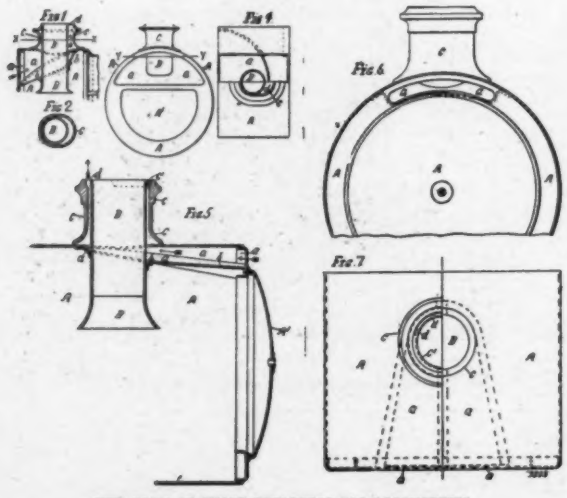
port to the main steam pipe are closed by the jockey valve. As the regulator handle is moved from the closed position the ports through the main valve are gradually uncovered by the jockey valve, and high-pressure steam is admitted simultaneously to the main steam pipe and to the low-pressure auxiliary pipe. When the main valve is on the point of moving the area of the passage through the regulator, by which steam can pass to the low-pressure chests is maximum, and further movement of the handle causes the main valve to gradually close this opening and also to increase the opening for the passage of steam from the boiler into the main steam pipe. The admission of boiler steam to the low-pressure cylinders is entirely cut off by moving the handle about 30 deg. from the shut position, when the engine, of course, commences to work entirely as a compound. By moving the handle still further over, the port for admitting steam to the main steam pipe is opened wider. Non-return valves are fitted to the front and back of the cylinders to prevent unnecessary back pressure on the high-pressure piston at starting in certain positions of the engine. These allow of the passage of steam from the low-pressure steam chests into the other end of the high-pressure cylinder. These valves only open when the pressure on one side or the other of the high-pressure piston is lower than the pressure in the low-pressure steam chest. Steam distribution to the high-pressure cylinder is by a 10 in. diameter piston valve working underneath; the other cylinders have flat slide valves working at the sides. A separate set of Stephenson link motion is used for each valve, and both high and low-pressure gears are reversed from the same reversing shaft by means of one screw. The leading dimensions are :—

Cylinder high-pressure, 19 ins. ; low-pressure, 21 ins. diameter.
Stroke, 26 ins.
Coupled wheels diameter, 7 ft. 0 ins.
Bogie " " 3 ft. 6½ ins.
Wheel base, engine, 24 ft. 3 ins.
" tender, 13ft. 9 ins.
" total, 48 ft. 3½ ins.
Boiler, length of barrel, 11 ft. 11 ins.
" diameter of barrel, second ring, 4 ft. 7⅞ ins.
" heating surface, tubes ... ... 1305·5 sq. ft.
" " firebox ... ... 152·8 " "
Total ... ... 1458·3 sq. ft.

Grate area, 28·4 sq. ft.
Working pressure, 220 lbs. per sq. in.

	T.	C.	Q.
Weights in working order, on bogie wheels	20	14	0
" " " driving "	19	11	0
" " " trailing "	19	11	0
" " " Total ...	59	16	0
Weight of tender in working order ...	42	18	2
Total of engine and tender ...	102	14	2

A New Form of Smoke Deflector for Locomotives.—Mr. H. A. Ivatt, M.Inst.C.E., Locomotive Engineer of the Great Northern Railway, has recently had engine No. 1,410, of the "Atlantic" type express passenger class on that line, fitted with the smoke-deflecting device patented by Mr. J. F. S. Cridland, of the L.B. & S.C. Railway. The accompanying drawings clearly show the arrangement as fitted to the engine mentioned above, and to quote the wording adopted by the inventor in his specification, the invention—

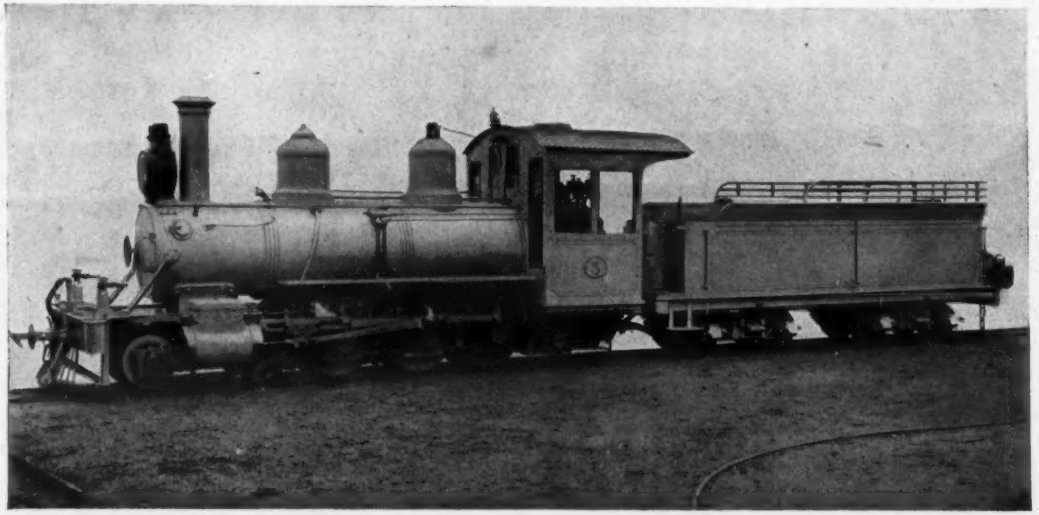


NEW FORM OF SMOKE DEFLECTOR FOR LOCOMOTIVES.

"Has for its object to prevent the smoke, gaseous products of combustion and steam, which issues out of the funnel, from beating down and striking the cab of the locomotive, and thereby obstructing the view of the engine driver. To the above end the invention consists in providing an air inlet duct or passage in the upper part of the front plate of the smoke box of the locomotive and above the smoke box door.

This air inlet duct has an upwardly inclined inner bottom converging from the shell of the smoke box round the internal pipe of the funnel, the external part of which is surrounded eccentrically by an oval or other shaped casing so set as to leave the exit of the passage or duct through the mouth of the casing at the back of the funnel; or the casing may be concentric with the funnel pipe, with the annular space so formed closed at the front leaving the exit at the back of the funnel. The rush of air through this air duct when the locomotive is running thus finds a vertical exit at the back of the funnel and thereby strikes up against the smoke, gas products, and steam as they issue from the funnel, and forces them upward and thus prevents them striking against the spectacle plate of the cab and obscuring the view of the engine driver."

Narrow Gauge Locomotive: Cape Government Railways.—Messrs. W. G. Bagnall, Ltd., of Castle Engine Works, Stafford, have built several 4-6-0 type locomotives for service on the 2 ft. gauge, Kalabas, Kraal-Hopefield section of the Cape Government Railways. The engines have outside cylinders driving the intermediate pair of coupled wheels which are flangeless, the front portion of the locomotive being carried upon a four-wheeled bogie. As originally designed the engines were to have two-wheeled trucks of the "Bissel" type, but it was afterwards decided to fit them with four-wheeled bogies. The main frames, which are of the bar pattern, are placed outside the wheels, necessitating the use of outside cranks, this being a customary practice for narrow gauge engines where the space between the frames —especially when the gauge is only 2 ft.—is very greatly restricted. The valve gear is of the "Stephenson" type, actuating slide valves above the cylinders through the medium of rocking



NARROW GAUGE LOCOMOTIVE FOR THE CAPE GOVERNMENT RAILWAYS.

shafts. The following are the principal dimensions :—

Cylinders	11½ in. in dia. by 16 in. stroke
Bogie wheels, diameter	1 ft. 10 in.
Coupled „ „	2 ft. 9 in.
Rigid wheel base	6 ft 6 in.
Total „ (engine)	10 ft.
Total length of engine over buffer beams ..	21 ft. 4½ in.
Bar frames	3 in. by 3 in. section
Length of boiler barrel	10 ft. 4½ in.
Diameter „ „	3 ft. 3 in.
Thickness of plates	.. 7/16 in.
Number of tubes	.. 168
Diameter „	.. 2 in.
Heating surface, tubes	380·86 sq. ft.
„ „ fire-box	40·47 „
Total	421·33 sq. ft.
Grate area	7·6 sq. ft.
Steam pressure	180 lb. per sq. in.
Height of boiler centre above rails ..	.. 4 ft. 8½ in.
„ from rails to top of chimney ..	.. 10 ft. 4½ in.
Weight of engine	20 tons 5 cwt.
„ on coupled wheels	16 „ 15 „

The tender runs upon two four-wheeled bogies with outside, skeleton pattern frames. The water capacity is 1,500 gallons, and 5 tons of coal are carried. The tank, which is fitted with a water gauge, is of the horse-shoe type, and the tender weighs 19 tons. Both steam and hand brakes are fitted.

The total length of engine and tender over buffers is 44 ft. 5 in.

A Locomotive "Secret" Revealed.—That remarkable locomotive production of 1903, the Great Eastern "Decapod" tank engine, about which much has been written but little understood by those outside railway circles, has turned up again—in the columns of the *Engineer*—after a period of oblivion extending back for over three years, this time in an entirely new guise. The engine was always regarded somewhat in the light of a mystery; and to those who have made a study of traffic conditions on the railways of this country, the necessity for a ten-coupled tank locomotive embodying so many special features as did the "Decapod" was always difficult to appreciate.

About the ingenuity and resourcefulness which Mr. Holden displayed in getting out the design there can be only one opinion. He showed himself then, if never before, to be in possession of an originality and skill in locomotive engineering matters which years of ordinary work would have failed to demonstrate; and it is certain that had everything else been favourable, the work done by the engine, in hauling the heaviest suburban trains and accelerating them with a rapidity and certainty approximating to that of electric traction, would have vindicated Mr. Holden's calculations.

An altogether better and more simple way out of the suburban traffic difficulty—which at the time of the "Decapod" experiment had become very acute indeed on the Great Eastern Railway—was, however, eventually found. The large number of six-wheels coupled side-tank engines of the 0-6-0 type was further increased, and the existing engines of the class were given larger boilers and fire-boxes and a higher steam pressure, when it was soon found that the engines, which are extremely simple and straightforward in design, had no difficulty in dealing with the enlarged trains demanded by the conditions of traffic. These trains consist of seventeen coaches of the new wide type, accommodating six passengers a side in the second and third class carriages, and four a side in the first-class; the complete train weighing 277 tons when fully loaded.

The "Decapod" locomotive is now being reconstructed at Stratford Works, and when she reappears it will be in the form of an eight-wheels coupled goods engine with tender.

There will be two 18½ in. by 24 in. cylinders outside the frames driving the second pair of coupled wheels; the third cylinder of the original design between the frames will have disappeared, and the forked connecting rod, one of the peculiarities of "Decapod," will, as a matter of course, have gone also. A new boiler is being fitted in place of the immense one, with its wide fire-box spreading out of the frames, which was such a marked feature of the original engine: and in its new state the locomotive will be able to haul fifty coal wagons, each of 20 tons capacity, which is equal to double the load taken by the standard six-coupled goods engines on the Great Eastern.

Other dimensions which apply to the engine in its new form are as follows :—

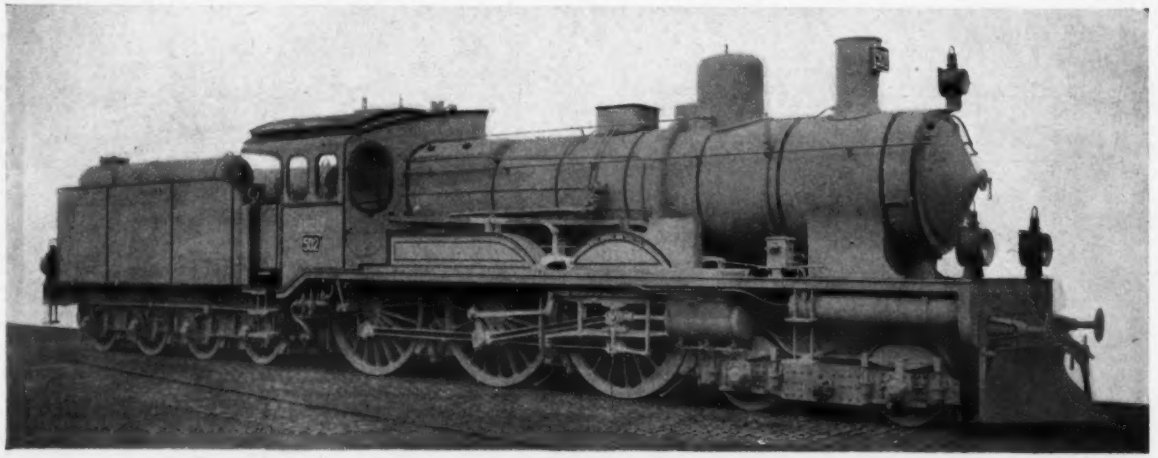
Coupled wheels	4 ft. 6 in. dia.
Boiler diameter	4 ft. 9in.
„ centre above rails ..	8 ft. 3 in.
„ steam pressure ..	180 lbs. per sq. in.
Heating surface, tubes ..	1738 sq. ft.
„ „ fire-box ..	131 „
Total	1869 sq. ft.
Number of tubes	285
Diameter „	1¾ in. dia. outside
Grate area	22·9 sq. ft.

A Heavy German-built Compound Locomotive.—The writer has received from Messrs. Henschel and Co., locomotive builders, of Cassel, Germany, a photograph, reproduced herewith, and particulars of a large four-cylinder compound passenger locomotive of the 4-6-0 type which they have built for service on the Bagdad

Railway. This is a standard gauge-line connecting Bussora and Koweit on the Persian Gulf with Konia, in Asia Minor, where a junction is effected with the Anatolian Railway which runs to Haidar Pacha, opposite Constantinople. The cylinder arrangement of these locomotives is similar to that employed for engines in de Glehn system compounds—that is to say, the two low-pressure cylinders are placed between the frames in the usual position below the smoke-box for driving the crank-axle of the foremost pair of coupled wheels, whilst the high-pressure cylinders are located outside the frames at the rear of the bogie and drive the second pair. Separate valve gears are used for each cylinder, the type throughout being Walschaerts'. Outside framing is used for the bogie and for the wheels of the tender, but the main framing is inside. The boiler is of large size, with a Belpaire firebox and extended smoke-box, the front of the latter being of conical formation, whilst the front sheets of the cab are brought together as a prow to reduce the effect of wind resistance. The engine is fired with liquid fuel, the supply being carried in two cylindrical tanks upon the tender. Forced lubrication and quick-acting Westinghouse brake apparatus are employed.

The dimensions are as follows :—

Cylinders, h.p.	...	13½ in. by 25½ in.	
,, l.p.	...	22 ,, ,,	
Bogie wheels dia.	...	2 ft. 11½ in.	
Coupled	...	6 ft 6 in.	
Bogie wheel base	...	6 ft. 2⅞ in.	
Coupled ,,	...	14 ft. 9 in.	
Total wheel base	...	26 ft. 10⅝ in.	
Boiler. dia. of barrel	...	4 ft. 9¼ in.	
,, height of centre above rails	...	8 ft. 7½ in.	
,, No. of tubes (serve)	...	126	
,, Length of tubes		13 ft. 9½ in,	
Boilers, dia. of tubes	...	2¾ in. outs.	
Heating surface fire-box	...	157·26 sq. ft.	
Heating surface tubes		2,118·05 ,,	
,, ,, total		2275·31 ,,	
Grate area	...	29·38 ,,	
Working pressure	...	213 lb. per sq. in.	
Total length over buffers	...	36 ft. 9¾ in.	
Weight of engine empty	...	59 tons, 10 cwt.	
Weight of engine loaded	...	66 tons 8 cwt.	



GERMAN-BUILT COMPOUND LOCOMOTIVE FOR THE BAGDAD RAILWAY.

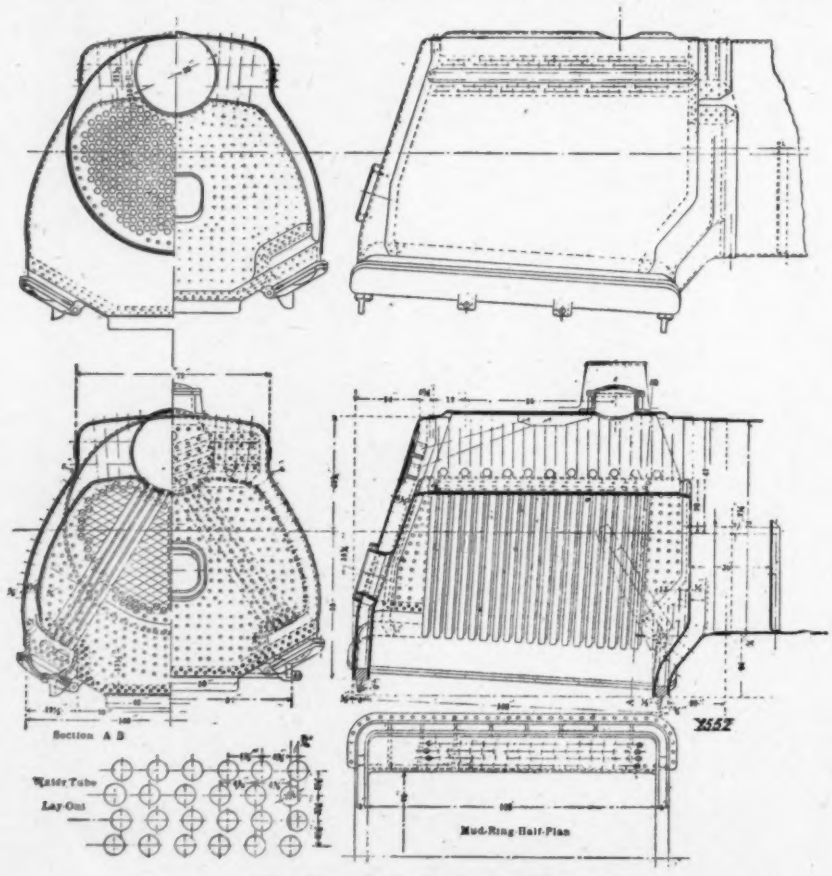
The weight is distributed as follows :—

On bogie wheels	...	...	...	20 tons 9 cwt. 3 qrs.
„ leading coupled	...	...	...	15 „ 5 „ 2 „
„ middle „	...	...	...	15 „ 6 „ 2 „
„ trailing	...	...	...	15 „ 5 „ 0 „

From these figures it will be seen that the design is fully in accordance with the latest standard for this type of locomotive.

The Riegel Water-Tube Locomotive Boiler.—A locomotive belonging to the Southern Pacific Railroad, and engaged in hauling express passenger trains, has recently been fitted with a water-tube boiler designed by Mr. S. S. Riegel, and the accompanying drawings, from the *American Engineer and Railroad Journal* of New York, clearly show the construction. The water-tubes are located in the fire-box, and the foundation ring, which is of cast steel, has water-pockets cast in it at the sides beyond the grates throughout its length, thus forming lower terminations for two nests of water-tubes, which extend from them diagonally upwards to the crown plate, which is slightly depressed to keep the upper tube terminations flooded.

The water-pockets have staying ribs cast integral with them, and the ribs are provided with holes to permit freedom of circulation. The water-pockets are covered over at the bottom by removable plates to provide openings through which the tubes can



THE RIEGEL WATER-TUBE LOCOMOTIVE BOILER.

be inserted and expanded, and through which the boiler can be easily examined and the tubes cleaned. The plates are hinged forward and back, so they will swing back out of the way when the bolts which secure them in place are removed, and they can be swung back into position by a few men, thus avoiding the necessity of lifting them into place. The steam joints are made with sheets of soft metal, and the water-tubes are so spaced that it is possible to pass a boring bar between them in order to remove defective staybolts, and they are kept sufficient distances from the flue, door and side sheets for accessibility for inspection and repairs.

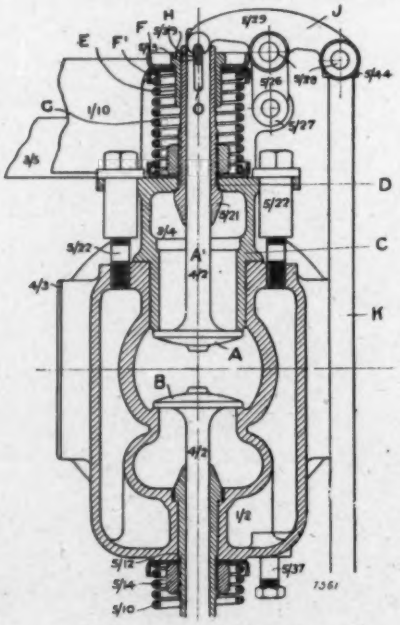
The steam space is of the Belpaire type for greater steam capacity and for simplicity of staying. Above the crown plate is provided a staying cylinder, which, with the crown plate, makes double thickness at the crown for tube ends, and this cylinder has sufficient flexibility to allow for expansion and contraction. Above the crown plate in the roof of the boiler is provided a combination man-hole and pop-valve turret. This gives a ready means of access for inspection purposes. The usual fire-brick arch is placed forward in the fire-box. This diverts the gases, and causes them to pass between the water-tubes and impinge upon the side plates, and the gases which have been cooled by contact with the water-tubes, are re-heated by the gases which pass round the nest of tubes and over the arch. In this way the heat is retained in the fire-box, which, together with the increased circulation, gives the water a chance to absorb it.

In the fire-box shown in the drawings there is a total of 768 sq. ft. of heating surface. This is very considerable, and is so arranged as to cause perfect and direct cycles of water circulation upward through the tubes and about the fire-box in general, which causes rapid heat absorption, prevents scale formation, makes expansion and contraction uniform, stimulates evaporation, and causes liberation of steam, making it possible to reduce combustion to about one-half the present rate. To allow of greater freedom of circulation about the fire-box, a plate is fixed 30 in. forward of the back tube plate. The top of this is below the upper tubes, and serves as a dam to keep the cold inlet water forward and away from the fire-box until it has been warmed to 300° or 312°, when it overflows the dam and meets the circulating currents about the fire-box. The necessary tube holes in this dam are not a tight fit for the tubes.

Automobile Engineering Notes.

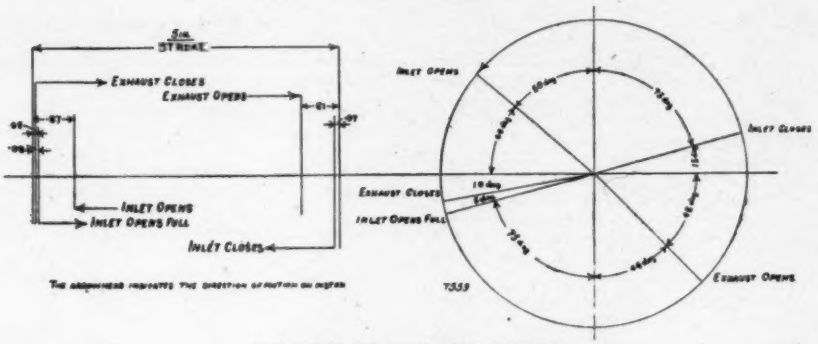
By ROBERT E. PHILLIPS, M.I.Mech.E., A.M.Inst.C.E.

The Auto-Mechanical Inlet Valve.—In our notes in the February issue we referred to the auto-mechanical inlet valve fitted to the engine of the Duryea car, but as we were unable to illustrate it, we deferred dealing with it at length. Through the courtesy of the Pilgrim's Way Motor Co., Limited, we are now able to illustrate this new valve as fitted to the engine of the new car they are about to place on the market. It will be seen on reference to the illustration that the valve *A* is superimposed above the exhaust valve *B*, so that it opens downwards, the seating forming part of a detachable box *C*, into which the inlet pipe leads. In the upper part of this box is fixed a long guide *D*, for the stem *A*1 of the valve to slide in. On the exterior of the guide *D* is a sliding sleeve *E*, which carries a pair of cupped washers, *F* and *F*1.



AUTO-MECHANICAL INLET VALVE.

Between the lower washer *F*1 and a similar washer on the top of the valve box *C* is a helical spring *G*, which operates to press the sliding sleeve *E* upwards on the guide *D*. Through the stem of the valve near its free or upper end is a slot *a*, and in the upper end of both the guide *D* and the sleeve *E* are corresponding slots. Through these three slots passes a cottar *H*, the length of which is such that it is retained in its position in said slots by reason of its ends engaging the lip of the cup-shaped washer *F*. The slot *a* is slightly wider than the thickness of the cottar, so that its sides do not contact the sides of the cottar. It will be seen that the pressure of the spring *G*, acting on the washers *F* and *F*1, operates through the cottar *H* to lift the stem *A*1 of the valve, and so keep the valve on its seating. Both the slot *a* and the slot in the guide *D* are of such a depth as will allow of an amount of relative movement between the stem of the valve and the guide equal to the amount the valve is designed to open. Adjacent to the upper end of the stem of the valve is pivotted a rocking lever *J*, which receives its motion from the cam on the half-time shaft through the rod *K*. The end of this lever over the valve is forked, and has its jaws shaped to engage the cottar *H*, so that the lever operates to depress the spring *G* through the cup washer *F* and the sliding sleeve *E*. The profile of the cam for operating the rocking lever is the same as that of the exhaust cam, so that all the cams are alike, each inlet cam being set to lay 93 deg. behind its exhaust cam. The diagrams show the relative actions of the cams, from which it will be seen that the inlet cam commences to depress the spring *G* when the crank is at 140 deg. on the exhaust stroke, and completes the depression when the crank has reached 15 deg. on the suction stroke, so that at the end of the exhaust stroke the valve is only retained on its seat by the pressure of the residual gases in the cylinder. It is consequently free to open by gravity as soon as the pressure of the said gases in the cylinder falls to that in the induction pipe, viz., to atmospheric pressure. The amount the valve opens is determined by the length of



AUTO-MECHANICAL INLET VALVE DIAGRAMS.

the slot *a*, as its fall is limited by the upper end of the slot coming into contact with the upper side of the cottar *H*. The cam retains the spring *G* fully depressed until the crank is at 140 deg. on the suction stroke, when it operates to gradually allow the spring to rise and lift the valve—which is now in contact with the washer *F* through the cotter *H*—and so restores it to its seat when the crank has reached 15 deg. on the compression stroke. It will be seen that this valve is absolutely automatic, as it opens by gravity, and is not dependent on the creation of a partial vacuum in the cylinder to cause it to open. It is also free to select its time of opening according to the conditions pertaining within the cylinder, which obviously vary according to the speed at which the engine is running. We think, therefore, that the claim made for it that it neutralizes the disadvantages of both the atmospheric and the mechanically-operated valve is well founded, since, in the one case, it obviates the necessity of using very weak springs, which need careful adjustment and frequent renewal, and, in the other case, it reduces the importance of extreme accuracy in "setting" the operating mechanism. There are other strong points in favour of this valve. For instance, it is not necessary to use such a strong spring as is used with the mechanically-operated valve, and therefore less power is absorbed in operating the valve and it is also less noisy, and the cottars and washers are not subjected to the hammering action inseparable from the use of both the atmospheric and the mechanically-operated valve. The lift—or in this case drop—of the valve is varied by interposing between the cam and the rod *K* a wedge-shaped slide by means of which the amount the spring *G* is compressed can be varied, and although this device has been used with mechanically-operated valves the action when employed with the auto-mechanical valve is quite different. When used with a mechanically-operated valve the effect is to both open the valve later and close it earlier, whereas when used with the auto-mechanical valve it only operates to close it earlier and does not interfere with its selective time of opening, which is always at the earliest possible moment, the result being that the throttling effect is obtained without altering the conditions under which the carburettor works.

Generative Systems of Electric Ignition.—Now that the magneto has obtained a firm foothold as a generator for ignition purposes, attention is once more being directed to generative systems in which an accumulator is used, a system employed in the early days by the firm of Mors. At first sight it does not seem to be a difficult problem to use a dynamo or generator for keeping the accumulators fully charged, but when one bears in mind the varying speeds at which the petrol engine of a modern motor car runs, the difficulty of maintaining a constant current will be appreciated. Various attempts have been made to cut the circuit in and out by means of a centrifugal governor, but none have been entirely successful. The Electrical Ignition Co. of Birmingham are introducing a generative system for both ignition and lighting purposes, in which the current is kept constant by means of an automatic cut-out. The generator, which is of the low-speed type, gives from 8 to 10 volts which enables two 4-volt accumulators to be charged in series. The automatic cut-out puts the generator in circuit when the voltage it gives rises above that

of the accumulators, the dynamo energising the coil at 4 volts, so completing the circuit. When the speed of the engine is reduced to a point when the voltage given off by the generator falls below that of the accumulators, the reverse current operates the coil and cuts the generator out. The electrodes are made up of alternate layers of pellets composed of oxides of lead and spongy lead. The pellets although hard have considerable porosity, which results in high conductivity and large current capacity. The separation of the positive and negative elements is attained by the use of containing porous jars or pots of considerable strength, their porosity being such that, although the electrolyte has free passage, the lead oxides cannot penetrate them.

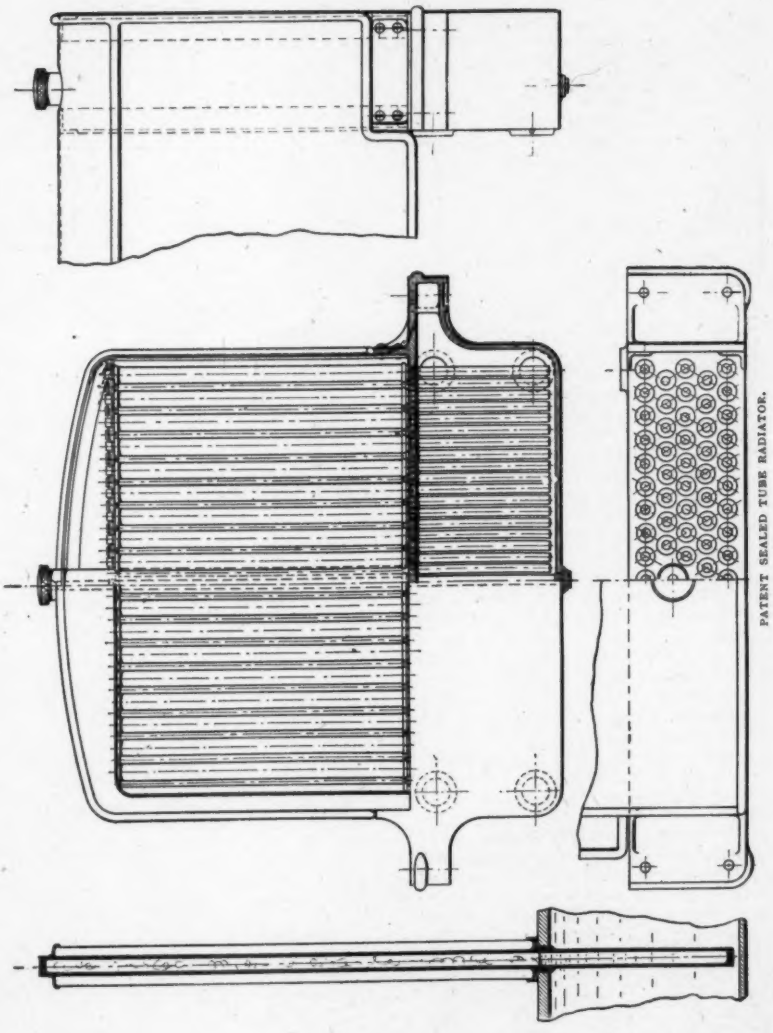
The latest development in generative systems is the V. and P. dynamo of Messrs. Vandervell & Co., of Acton, which automatically maintains a constant current with varying engine speed. In this dynamo neither the field magnets nor the armature is rigidly fixed. The field magnets are rotated by being driven by a belt or other suitable means from the engine, the current being taken through two collecting brushes to the windings of the field magnets, which have four poles. The armature is mounted so as to be free to revolve between the field magnets but is prevented from so doing by means of a specially constructed brake. This consists of carbon brake blocks acting on a cast-iron drum, the said blocks being mounted on flexible bands which can be drawn up to increase the friction on the drum by means of a screw. The machine is fitted throughout with ball bearings, so that the only friction to prevent the armature rotating is the aforesaid brake. When the dynamo is running the field magnets exert a variable pull on the armature. If the magnets are rotating slowly the pull is insufficient to overcome the resistance of the brakes so that the armature remains stationary and the current is generated. When the speed of the magnets increases, the current also rises until it reaches a point at which the pull of the magnets is so great that the brake resistance is partially overcome and the armature begins to rotate. This speed of rotation however is only such as will keep the current of constant value, or put in another way, whatever may be the speed of the field magnets their speed relative to the armature remains constant, with the result that the output is also constant. With this generator it is only necessary to use a cut-out which breaks the circuit when the speed of the engine drops below that necessary to drive the generator at a speed which will produce a voltage of a predetermined value.

Motor Omnibuses.—At the present time the demand for motor 'buses is so great that any firm in a position to supply has no difficulty in obtaining a trial. The types of vehicles used by the various London companies is therefore of interest. The following list may be taken as fairly accurate, though various new types are being constantly put on the road.

Company.	Distinctive Name.	Type.
London Motor Omnibus Co.	"Vanguard"	Milnes-Daimler. De Dion Bouton.
London & District Motor Omnibus Co.	"Arrow"	Straker & Squire.
Motor Bus Co.	"Dart"	Panhard - Levassor.
London General Omnibus Co.	"General"	Straker & Squire. De Dion Bouton. Gobron-Brille. Orion.
London Road Car Co.	"Union Jack"	Germain. Durkopp. Clarkson (steam).
London and Suburban Omnibus Co.	"Kingsway"	Crossley - Leyland.
London Power Omnibus Co.	"Pioneer"	Scott-Stirling.
Thomas Tilling, Ltd.	—	Milnes-Daimler.
Associated Omnibus Co.	—	" "
City and Suburban Motor Omnibus Co.	—	De Dion Bouton.
Victoria Omnibus Association.	"The Old Vics"	Straker & Squire. Orion.
Rapid Road Transit Co.	"Rapide"	Ducommun.

According to the *Commercial Motor*, the number of 'buses of the various leading makes was on the 2nd of April last as follows: Milnes-Daimler, 153; Straker-Squire & Bussing, 80; De Dion Bouton, 34; Durkopp, 27; Crossley-Leyland, 13; Ducommun, 10; Clarkson, 9; Gobron-Brillé, 8; Orion, 8; Scott-Sterling, 7 other makes, 7.

The Sealed Tube Radiator.—The honeycomb form of radiator has proved itself such a constant source of trouble that any new type which will give equal efficiency in relation to size and weight, and not be subject to the objection that it will sooner or later develop a tendency to leak, will come as a boon and blessing to automobilists. Such a one appears to be the Patent Sealed Tube Indestructible Radiator of the Lune Valley Engineering Co. The principle on which this radiator is constructed will best be understood from the drawings. It will be seen that the radiator consists of a lower box, which is perforated on its upper side


PATENT SEALED TUBE RADIATOR.

to receive a series of tubes. These tubes, which are each independently screwed into the upper side of the box, are plain where they pass into the box, but are gilled above. These tubes are sealed at each end after being partially filled with a liquid having a low boiling point and having the air remaining extracted. The water to be cooled is circulated through the lower box, which causes the liquid in the tubes to boil, and thus extracts heat from the water, distributing it equally over the whole of the cooling surface of the tubes. The fluid vapour in the upper portion of the tubes is continuously being condensed by the cold air passing through the gilled surface of the tubes, so that the cycle of events occurring in each tube is continuous, which is not the case in a radiator in which the water has a number of parallel routes to select for its course.

The advantages of this radiator appear to be: Ease of repair, owing to each tube being separate and capable of being removed and replaced in a few minutes, without removing the radiator from the frame of the vehicle; impossibility of leakage, owing to the freedom for expansion and contraction, by reason of the tubes being fixed at one point only; reliability, owing to the fact that the fracture of any number of tubes does not cause loss of water, but only reduces the efficiency of the radiator by the number of tubes affected. A further advantage arises from the fact that as the liquid in the tubes does not commence to boil, and therefore to reduce the temperature of the water until a certain temperature has been reached, the efficient temperature for the engine is reached in less time than required with the ordinary type of radiator.

Electrical Notes.

By ANDREW STEWART, A.M.I.E.E.

Electric Power in the Factory.—The growth of large electric power companies, whose distributing network covers a large area, embracing industrial districts of all kinds, has caused the electrical engineer to devote attention to many problems of a by no means electrical nature; conversely, the number of people in whose everyday life applied electricity plays a more or less important part, or who rely to a greater or less extent upon it for carrying out industrial operations, are rapidly increasing. Moreover, the diverse working conditions of many factories has led to the introduction of special appliances to meet prevailing conditions in a more satisfactory manner than would be the case with a simple electric motor. We have, for instance, special systems and apparatus for obtaining wide and economical speed control, with even driving torque such as is necessary in paper manufacture, calico printing, and newspaper work, or systems for preventing the excessive fluctuations of the load from being transmitted back to the generating station, or causing violent fluctuations of current in the mains from which the motors are supplied; as, for example, electric winding plants at collieries, or rolling mill motors, where for periods of a few minutes at a time the load, may suddenly rise to several hundred horse-power, and as suddenly decrease to a mere fraction of this amount. All these systems involve auxiliary motors, or machines of special design, with which the mechanical engineer is generally unfamiliar. Apart from this, there is a tendency to introduce higher pressures than formerly. The upper limit of supply was until recently 500 volts, but voltages of the order of 1,000–5,000 volts are likely to become common for large alternating current motors in the early future. Already several power-supply companies deliver high-pressure current to the consumer, on whose premises it is transformed down for small motors. But in order to avoid capital charges for transformers, large motors are operated direct on this pressure, which gives a further advantage in that the losses in transformation are eliminated.

In connection with this latter point, Mr. Kenneth R. Stuart referred, in the course of a recent lecture in Sheffield, to the fact that the local authority in that town, who supply two-phase alternating current for power purposes, give a supply at 2,000 volts and have a 110 horse-power motor working at

this pressure in a works. As a matter of fact, when the works owner can avoid the capital cost of transformers, or obtain his energy at lower cost per unit, by taking high-pressure supply, there is no reason whatever why he should not do so. With alternating current motors, even when wound for high pressure, the actual starting gear, being connected to the armature, or rotor, which may be wound for 200 volts or thereby, is therefore at a pressure which is not over the usual low pressure found in most works. Hence, although the stator, or field magnet, of the motor does receive high-pressure current, no additional risk is involved, as this high voltage current is not directly handled.

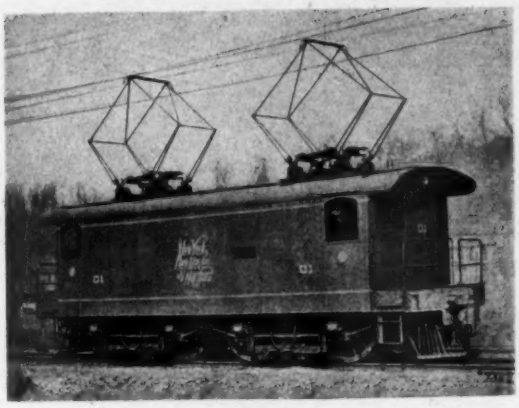


FIG. 1.—COMBINATION SINGLE-PHASE AND DIRECT CURRENT LOCOMOTIVE.

It appears from Mr. Stuart's paper that there are several small rolling-mills in the vicinity of Sheffield which are electrically driven. One mill has a set of roughing and finishing rolls. The former, 18 in. diameter, are belt driven from the finishing train, and run at 60 to 90 revolutions per minute. They are fitted with a heavy fly-wheel to take the load when the metal enters the mill. The bars on entering the mill are 5 to 6 in. thick, and weigh 65 to 165 lb. The finishing train has five housings of 10½ in. rolls running at 180–280 revolutions per minute. The motor is of 400 horse power. The finished product is of round, flat, angle, and tee section. The motor, which runs at the speed of the finishing rolls, drives these direct, and has the speed regulated by a liquid resistance.

It does not appear that there are any large reversing mills equipped electrically, though the lecturer, in the course of his paper, stated that the Ilgner system* is the only satisfactory method of driving such mills.

In connection with this question of electric driving in factories, it is interesting to note that Mr. E. R. Douglas, in a recent issue of *The Electrical Review* (New York), after going into the now well-known advantages of electric driving in so far as they affect the shop arrangement, states that the adoption of a carefully planned electrical installation will reduce the direct and indirect labour charges on the product by 10 per cent., and as the cost of power in most factories is a small proportion of the total cost of production, about 2 per cent., while the labour costs may be anything from 25 to 50 per cent, it follows that the indirect results of the introduction of electric driving, viz. reduction in labour costs, due to greater convenience and flexibility of the electric drive, is sufficient to pay all the power expenses of the factory, even assuming that there is no actual saving in power costs directly due to the introduction of a more economical system of power distribution. As the comparison of the cost of production is interesting, we reproduce the figures given by Mr. Douglas:—

	Mechanical Drive. Per cent.	Electrical Drive. Per cent.
Material...	50	50
Labour { Direct	30	27·3
Labour { Indirect	10	9·1
Power	2	2
Sundries, repairs and maintenance	3	2·7
Interest and depreciation on plant	4	3·6
Insurance, taxes, &c. ...	1	·9
	100	95·6

The Electric Locomotives for the New York, New Haven, and Hartford Railway.—These locomotives embody

FIG. 2.—ARMATURE OF SINGLE-PHASE MOTOR ON ELECTRIC LOCOMOTIVE.

* ENGINEERING REVIEW, September, 1905, p. 261.

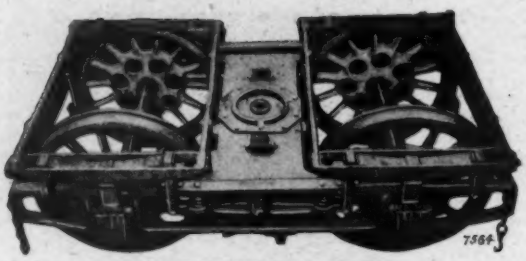


FIG. 3.—TRUCK WITHOUT THE MOTORS.

several features not hitherto incorporated in electric locomotives and the fact that they are designed for operation both on direct current, third rail, and single phase alternating current, with high-pressure overhead trolley wire, renders them especially interesting to engineers. The locomotive is shown, Fig. 1. It is mounted on two four-wheel trucks, on the side of which can be seen the arrangement for picking up the current from the third rail, while on the top of the cab will be seen the pantograph type collectors for collecting the high-tension current from the 11,000 volt trolley wire, which is 22 ft. above the track.

The frame, cab, and trucks are the work of the Baldwin Locomotive Works, and the electric equipment is by the Westinghouse Electric Company. The cab is of sheet steel on a framework of "Z" bars, the transformers, controllers, &c., are carried on a steel frame, built into the cab; and anchored to the floor and ceiling.

The trucks are each mounted on four 5 ft. 2 in. wheels, the wheel base being 8 ft. The side frames are of forged steel, and the steel bolster carrying the centre plate is of pressed steel. The centre plate is 18 in. diameter. The truck centres are 14½ ft. apart.

The high-pressure current as it passes from the bow trolleys goes to two step down transformers. These are duplicates, and while one only could be used, the use of two gives more even distribution of the weight, and the breakdown of one does not entirely disable the locomotive. These transformers reduce the line pressure to 450 volts, which is the normal working voltage of the motor on the alternating current system, while for direct current the usual voltage of 550 to 600 is supplied direct to the motors.

The main controllers, which can operate on both direct and alternating current systems, are operated from master controllers at each end of the cab, so that not only is it unnecessary to turn the locomotive, but two locomotives may be operated together, with only one driver in front of the leading locomotive.

There are four motors, one on each axle, each with a capacity of 250 horse-power for

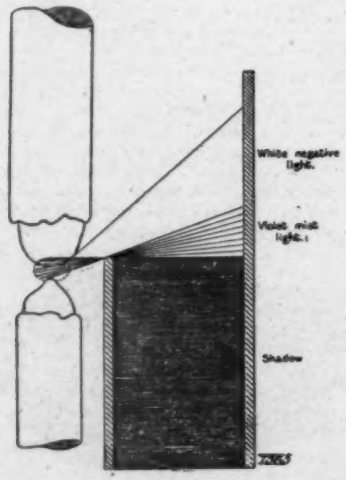


FIG. 4.

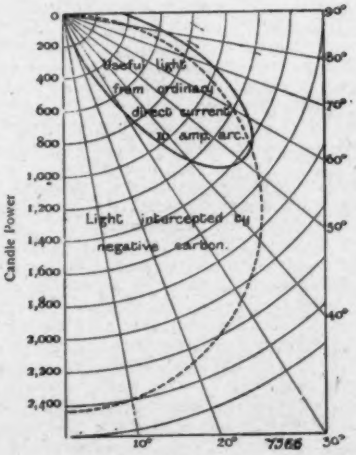


FIG. 5.

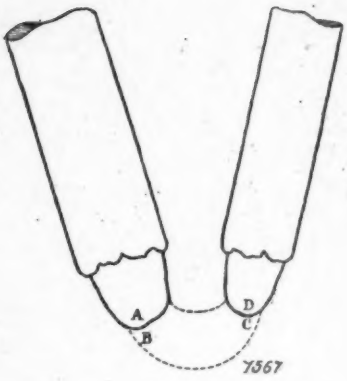


FIG. 6.

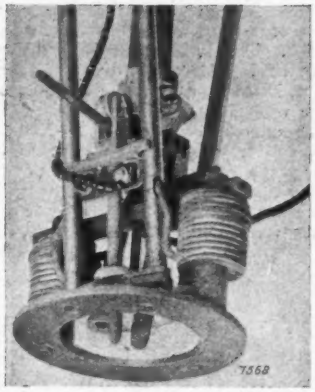


FIG. 7.—MAGNETIC RING CONTROL OF CARBONE ARC.

short periods, and a normal continuous rating of 200 horse-power each or 800 horse-power total. The armature is built directly on the axle, thereby avoiding gearing; the speed at full load is 225 revolutions per minute. The remarkable feature of the locomotives is the method of suspending the motor, and transmitting the driving torque to the wheels. The armature of one motor is shown (Fig. 2). The motor is of the compensated series type, and in general arrangement bears a strong resemblance to the ordinary series direct current motor, almost the only changes introduced being compensating coils to eliminate the tendency to spark at the commutator. This type of motor must not be confounded with the single-phase motors which are to be employed on the electrified section of the London, Brighton and South Coast Railway, which are of the compensated repulsion type as developed on the continent by the Allgemeine Electricitäts Gesselschaft.

The armature is not built directly on the car axle, but on a separate shaft through which the car axle passes, there being a clearance space of $\frac{5}{8}$ in. all round. At each end of this armature shaft is a disc from which projects seven pins, these enter corresponding pockets on the wheels of the truck (Fig. 3). Round each pin is a spring having the coils progressively eccentric; though these are strong enough to carry the weight of the armature, they are intended primarily for transmitting the driving torque to the wheels, and in fact, form an elastic coupling. In addition, any end thrust due to lateral movement of the motor armature is taken by helical springs, which are inside the pins, and press against the covers of the pin pockets on the wheels.

Each locomotive is capable of handling a 200-ton train on local service, at a maximum speed of 45 miles per hour, giving a schedule speed of 27 miles per hour. They can also handle 250-ton through trains at 40-50 miles per hour, while heavier trains will be handled by two locomotives.

Flame Arc Lamps.—A paper, recently read to the Institution of Electrical Engineers, by Mr. Leonard Andrews, on Long Flame Arc Lamps, directs the attention of engineers generally to a type of lamp which has lately attracted much attention among

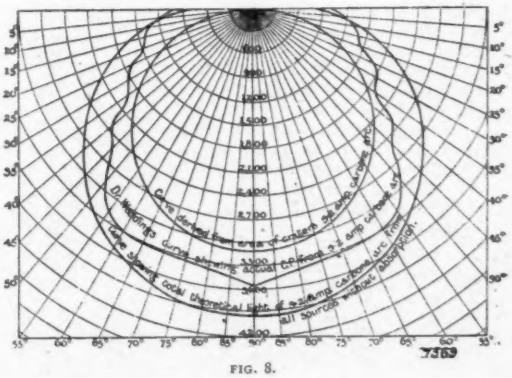


FIG. 8.

electrical engineers, and those borough engineers who are responsible for street lighting. The lighting of Queen Victoria Street at Blackfriars, and at the Mansion House, London, as well as a whole street which was illuminated temporarily during the electrical exhibition at Newcastle, stimulated interest in this type of lamp, more particularly as its efficiency is much greater than any other arc lamp, indeed it brings arc lighting down to a price which, for a given amount of illumination, cannot

FIG. 9.—EXTERIOR LIGHTING BY MERCURY VAPOUR LAMPS

be approached by any other artificial illuminant, the mean hemispherical candle-power per watt being about five times that of the ordinary type arc lamps generally used.

As is well known, much of the light of an ordinary arc lamp is intercepted by the negative carbon, as it is directly in front of the most luminous part of the positive carbon—viz., the crater. This will be clear from Figs. 4 and 5. The former shows the light distribution from the carbons, and the latter shows, by means of the broken curve, the total light from the positive crater of the arc, and in a full line, the useful light from the lamp.

There are several types of these long flame arc lamps, though generally they depend upon carbons having a core more or less impregnated with metallic salts, such as calcium and magnesium.

The general arrangement of the carbons of these long flame arc lamps is as in Fig. 6. As the arc tends to rise, several devices have be n tried to keep the arc in the position shown by the broken lines (Fig. 6). In the "Carbone" chemical lamp this is effected by the stray field of a small electro magnet (Fig. 7).

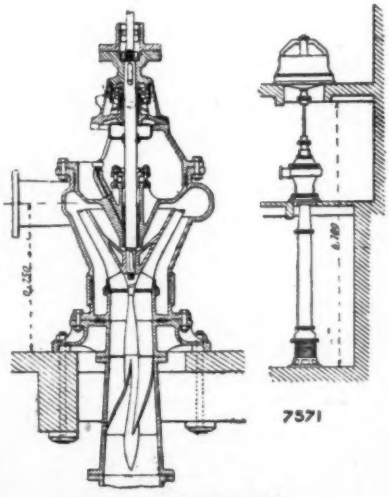
The excellent light distribution of such a lamp will be apparent from Fig. 8, where the light due to the craters and the total illumination of the lamp is given. The colour of the light is yellow, and it is therefore unsuitable for colour matching, though it is superior to the ordinary arc lamp for penetrating fog.

Exterior Lighting by Mercury Vapour Lamps.—The first installation of "Cooper-Hewitt" mercury vapour lamps for exterior lighting in this country is now to be seen outside the *Tribune* offices in Bouverie Street, E.C. The six lamps installed are each of 800 candle-power, enclosed in a specially-designed weather-proof lantern, and give a brilliant mauve light, which illuminates the large building with startling brilliancy. The lamps do not differ from the ordinary form now used extensively for indoor lighting. They are 45 in. long by 1 in. diameter, and work on a 200-volt. direct-current circuit. It will be remembered that they are, says the *Electrical Review*, started by tilting the tube so that the mercury flows from one electrode to the other in a small stream. The metallic mercury momentarily connects the two electrodes, and as the stream breaks an arc is formed, which increases the vapour pressure. The vapour then becomes luminous. The lanterns, accordingly, had to be constructed in such a manner as to make the tilting of the lamps possible. They are suspended on trunnions, by which the lantern and lamp are tilted together by hand. The weatherproof lanterns outside the *Tribune* offices were designed by the British Westinghouse Co., who hold the patent rights of the "Cooper-Hewitt" lamp for the United Kingdom.

Engineering Progress.

Electric Pumps at Nancy Waterworks.*—To supplement the existing hydraulic pumping plant at the Nancy Waterworks, three sets of electric pumps have been installed. The triphase, 220-volt motors are asynchronous 6-pole machines, mounted on vertical shafts and running at a speed of 980 revolutions per minute. Each motor develops 85 h.-p. and consumes 70 kilowatts in normal work; the slip is between 1½ and 2 per cent. The pumps are of the Maginot helicocentrifugal type, which will deliver nearly 150,000 galls. per hour when run at a speed of 980 revolutions per minute. The steel ball race has a spherical base (radius 5½ in.), so that the race is self-adjusting on a plane at right angles to the shaft. Since the rotary part of the pump turns in a chamber exposed to the pressure in the delivery pipe, the pressure on the thrust block is considerably reduced. The gyratory motion of the water in the suction pipe is counteracted, and the suctional power of the pump increased by means of the fixed spirals shown in the lower part of the illustration. The bottom of the suction pipe is fitted with valves for preventing the return of water to the suction tank when the pump is stopped.

* *Le Génie Civil.*



PUMPS AT NANCY WATERWORKS.

The motor and pump are connected by a flexible coupling, capable of a certain amount of vertical play, independent of either. This coupling consists of a thin steel shaft, 1½ in. in diameter, terminating at each end in shrunk-on collars, each of which carries two vertical slots engaging with cottars in the sleeves of the motor and pump shafts. The connecting shaft is thus able to move vertically for a certain distance, and thus compensate for the upward thrust of the pump room floor in flood time. It also helps to distribute the pressure of the pump and motor on their respective thrust blocks.

Preserving Telegraph Poles.—In view of the little success attending the various methods of impregnation for preventing the rotting of telegraph poles and wooden standards for electric conductors—even the best treatment, namely, charring and painting with tar preparations, only increasing the life of the poles by about 10 per cent.—Loewit* recommends embedding the base of the poles in concrete and surrounding them with a concrete pediment, projecting a short distance above ground. The pediment is made in two vertical parts, which are placed in position when the pole pit has been filled with concrete to within about a foot of the top. The filling of the pit is then completed, the concrete rammed, and the space between the pediment and the pole filled with thick cement mortar, finished off with a slope at the top so that the rain-water will run away. This treatment he finds highly efficient, poles exhibiting no signs of rotting after standing three years in places where they were formerly quite worn out in that time. It has the additional advantage of being easily and cheaply applied to poles already in position, and preserves from further decomposition such as have already begun to go but are still fit for use.

Minimising Danger from Electrical Apparatus in Fiery Mines.—The results of a long series of tests performed at the Gelsenkirchen Testing Station, with a view to minimising the risk of igniting firedamp by the sparking of electromotors and other appliances in fiery mines, are reported by Beyling in *Glückauf*. Sheet-metal casing is regarded as applicable only for machines that are not liable to get hot while in use, and will not keep out firedamp unless all the joints are perfectly hermetical. Wire gauze affords good

* *Elektrotechnik und Maschinenbau.*

ventilation, and is both cheap and light, but lacks strength, and is a source of danger from the gas burning inside. Laminated baffle rings also facilitate ventilation, but require the use of an internal fan. They are, however, stronger than gauze and not liable to burn. The best protection is afforded by an oil bath, which prevents access of gas to the sparking parts; but its application is of a limited character. The following recommendations are given to improve the safety of the apparatus. In all casings, except those combined with an oil bath, the sub-division of the internal space into large compartments with communicating narrow orifices should be avoided. All joints in the casings should be fitted with broad, smooth flanges, and any packing used—though this is not desirable—should be laid so that it cannot be forced out of place by any internal air pressure. Shafts traversing the casing should run in metal bushes, at least 2 in. wide, the holes for the leads should be filled up with insulating material, and nuts must be locked so that they cannot work loose and permit leakage. Fully enclosed casing must be strong enough to stand a pressure of 8 atmospheres, and must be free from holes for relieving pressure. Wire gauze casing should be of the same gauge as that for standard pattern safety lamps, of bronze or galvanised steel wire, and free from defects; and the total protective surface (two layers at least, $\frac{1}{8}$ to $\frac{1}{4}$ in. apart) should be at least 37 sq. in. per 100 cubic in. of internal space. If the surface is large the gauze should be supported by ribs. The gauze should be stretched in rigid frames forming removable covers, mounted in such a manner that no internal flame can travel along the surface, or any inflammable substance fall thereon; and shields of perforated sheet metal, etc., should be provided.

For laminated baffle ring casing the rings should be 2 in. wide, $1\frac{1}{10}$ in. thick, and set not more than $\frac{1}{10}$ in. apart. They should be of bronze, brass, or tinned or galvanised steel, and sufficient in number to prevent high internal air pressure, unless all parts are made extra strong. They should be attached to removable covers and shielded from external injury. In the case of oil-bath casing, enough oil must be provided to prevent any sparks forming above the surface even when the oil is disturbed, the height of the oil level being marked on the casing by the maker after a practical trial, and means provided for observing the actual level without removing the casing. Contacts, or the like, below the oil level must be formed so that no extensive decomposition or gasification of the oil can ensue when the current is passing, or in making and breaking contact.

Impregnating Pit Timbers.—According to Seidenschnur,* the experiments made in Silesian collieries have demonstrated that simple steeping in tar oils or other antiseptic solutions is ineffectual under the conditions prevailing in mines, it being necessary to force the liquid into the substance of the wood by the aid of a vacuum and pressure. As regards the solutions to be used, good results are said to have been obtained with the Weise and Hoettger methods, in which the zinc or magnesium compounds of B-naphthalene sulphonic acid, or sodium and zinc silicofluorides, are used, which substances have the advantage of not attacking the wood fibres. Another liquid, that of Wolman, consists of sulphates of iron and alumina, together with ammonium salts of certain organic acids, such as acetic acid. By means of these latter ingredients, the sulphuric acid liberated from the sulphates under the influence of heat is neutralised. At the same time the liberated acetic acid does not affect the wood, whilst the ammonium sulphate formed helps to render the wood uninflammable.

* *Glückauf*.

The Use of Windmills for Electrical Supply.*—Prof. La Cour recently carried out a series of experiments on windmills for the Danish Government at Askow. The object of the experiments was the selection of the best type of windmill and the best arrangement of generating plant.

Prof. La Cour found that a properly designed four-vaned motor gave superior results to any other type, especially as regards the suitability of speed for dynamo driving with moderate speed reduction. The power available from a given mill varies with the following expression:—

$$\text{H.P. developed} = \frac{\text{Area of vane surface in square metres} \times \left(\text{Speed of wind in metres per second}\right)^3}{1{,}250}.$$

Thus, with a vane area of 12 sq. metres and a wind velocity of 6 metres per second, the horse-power available = 2. With velocities of 4, 8 and 10 metres respectively, the horse-power = $\frac{1}{2}$, 5 and 10 approximately, or, allowing for loss due to air friction, the available horse-power in the four cases would be about $\frac{1}{2}$, $1\frac{3}{4}$, $4\frac{1}{2}$ and $8\frac{1}{2}$. The windmill should be self-adjusting as regards the direction of the wind.

In order to maintain a uniform supply, some form of reserve supply must be available, which can be drawn on during windless periods. The most suitable reserve in the case of large installations consists of a petrol motor, and for small ones of a horsed capstan. The employment of such a reserve reduces the cost as compared with that of accumulators sufficiently large to meet all the conditions unaided.

As an example of the cost of such an installation suitable for a small village, Prof. La Cour gives particulars of a station which has been supplying 450 incandescent lamps as well as a few arc lamps and motors for over two years at Askow.

* *Electrical Review*, April 20th.

Wind Motor	£165
Petrol Motor (as reserve)	165
Accumulators	275
Dynamo	50
Gear	19
Switchboard and cell switch	19
Base	110
Mains	70
Total	£873
Attendance, oiling and starting wind motor	£11 0
Attendance, &c., for petrol motor (during 30 days in the year at 4s. 6d.) ...	6 15
Petrol consumption per annum ...	11 0
Lubricant	4 10
Total	£33 5

The receipts for energy would amount to £140, giving an excess of receipts over expenditure of at least £105, or about 12 per cent. on the capital expenditure of £873. The cost of such an installation for an ordinary farmhouse is estimated at about £193, and the great advantage of such installations to the peasant population has, according to the *Elektrotechnik und Maschinenbau*, led to the recent construction of a considerable number of them in Denmark.

The Nitrifying Bacteria.—In the course of a paper published in a recent issue of the Proceedings of the Royal Society, H. Chick gives an interesting *resumé* of the facts now known about the bacteria which oxidise the nitrogen in sewage. This work is effected in two distinct stages, the ammonia being first converted into nitrites by the action of *B. nitrosomonas*, whilst the conversion of these nitrites into nitrates is effected by the agency of quite a distinct bacterium, known as *B. nitrobacter*. These bacteria swarm not only over the aggregate in a sewage filter in proper working order, but are also to be found in enormous numbers in the effluent. Perhaps the most astonishing fact about them, considering the work they accomplish, is that a pure culture of neither can multiply in a medium containing more than a trace of organic matter, and the presence of a small quantity of ammonia will also inhibit the growth of *B. nitrobacter*. It was this fact which prevented the earlier recognition and isolation of these bacteria, since they are incapable of multiplying in any of the ordinary nutrient media, such as sugars or peptones. They were first isolated by Winogradsky, who used a silica-jelly medium impregnated with inorganic salts. To account for the fact that they live and thrive in sewage filters, it is suggested that this may be due to symbiosis—that is to say, the presence of other bacteria makes it possible for these varieties to thrive. It is also possible that the organic matter in such filters, when properly working, is mainly confined to the upper layers. It appears that there is no absorption of ammonia previous to its oxidation, as has been sometimes suggested, but the bacteria concerned are so voracious that they can oxidise this completely to nitrates in the course of the short time taken for the sewage to flow through the filter. According to *Engineering*, the experiments described in the paper indicated that continuous filtration was very much more effective than the contact-bed system; but it is necessary to add that the sewage was sprinkled over the surface of the filter, and was thus exceptionally well aerated. It was further found that these nitrifying bacteria were very sensitive to temperature, their activity being greatly reduced by cold, a difference of 3° to 5° Fahr. in the temperature of two filters having a very marked effect on the character of the effluent.

The Melaun Tramway Rail-Joint.—To prevent the jolting, and consequent wear, of the ordinary butt joints of grooved tram-rails, the Berlin Tramways Company has adopted the Melaun joint (says Kueppers in the *Zeitschrift des Oesterreichischen Ingenieur und Architekten-Vereins*), in which the rail-head is cut away for a certain distance at the ends, and is replaced by a headed fishplate about 10 inches long, so that, instead of the single transverse fissure, there are two, one on either side of the actual joint (Fig. 1, plan, Fig. 2, elevation). At the same time, as shown in Figs. 3 there is no longitudinal fissure on the rail-head, as in the Schmidt joint, and the broad bases of the fishplates on either side rest on the rail-feet and check any tendency of the rail-ends to give under the weight of the cars.

To put in these joints on existing lines the fishplates and electrical connections are removed and the rail-head is sawn through crosswise each side the joint and cut away with a hammer and chisel between the two cuts, the two rail-ends having previously been fastened with temporary fishplates to give proper alignment for the chisel cut. The head on the new fishplate is somewhat higher than that of the rails, and is afterwards levelled down by means of a special milling machine. Finally the joint-head is gone over with a heavy file. In the modification shown in Fig. 3 the ends of the rail-heads

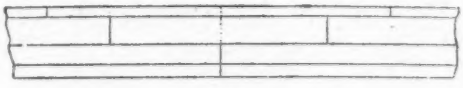


FIG. 1.

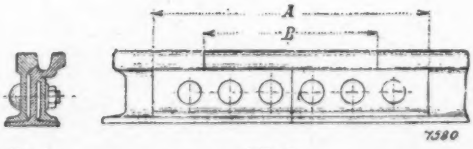


FIG. 3.

FIG. 2.

THE MELAUN TRAMWAY RAIL JOINT.

are cut down on the slope with a milling machine which cuts both rails at once.

Nancy Electric Funicular Railway.—In contrast to the ordinary type of funicular railway, in which two cars are attached to the opposite ends of a cable and run up and down alternately, the Nancy railway is arranged on the continuous system, this plan having been adopted by Bernardet (Memoirs de la Société des Ingenieurs Civils de France), as enabling the number of cars to be varied in accordance with traffic requirements. The cars can be run at intervals of twenty seconds, so that, with six seats per car, 1,080 passengers can be conveyed in the hour; and the use of these small cars enables a light, narrow gauge track to be employed, and generally reduces the cost of the installation.

The cable consists of twin crucible cast steel 1 in. ropes, each strong enough to carry the full load. They are superimposed, connected together every 5 ft. by bolted plates (Fig. 1), and are passed over top and bottom pulleys of equal diameter. The bolted plates engage in recesses in the driving pulley, and every second plate carries a grooved wheel running on a middle rail, this plate also engaging with a grip on the car. The cable being supported every 10 ft., a counterpoise of 24 cwt. is sufficient to keep it taut. There is no slip of the ropes on the pulley, so that if kept greased or tarred, they will last indefinitely.

The tracks are 77 in. apart, between centres and of 29 in. gauge. The rails, 18 lb. per yard run, are mounted on longitudinal oak sleepers, tied at intervals of 7 ft. Power is supplied from the town electric mains by three conductors, giving a difference of potential of 440 volts at the terminals, and actuating a 29 h.p. continuous current motor at the top station, which drives the 76 in. pulley through a second motion and bevel gearing (Fig. 2). An electric band brake comes into operation, whenever the circuit is interrupted, by the release of a counterpoise. A hand brake is also provided on the pulley, strong enough to stop the motor. When the number of passengers descending is greater than those making the up trip, the motor acts as a dynamo, delivering current to the electric main and serving as an automatic governor. By means of a combiner, similar to a tram controller, the speed of the motor can be varied between zero and 40 in. per second.

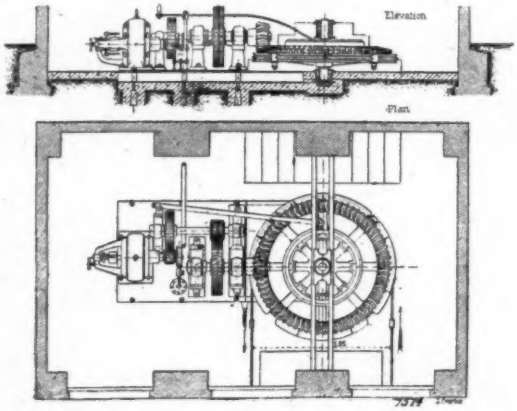


FIG. 2.

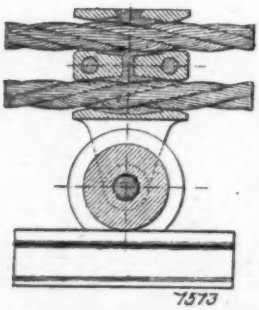


FIG. 1.

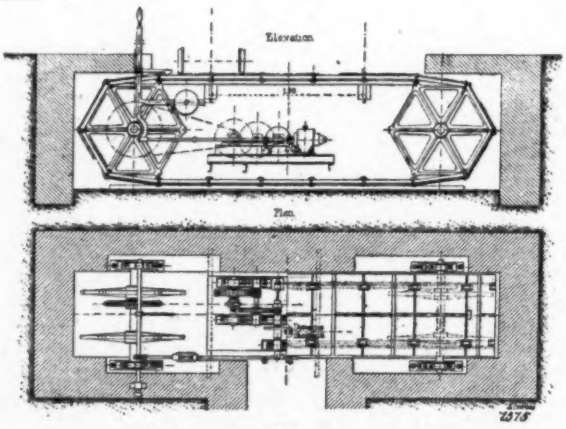


FIG. 3.

NANCY ELECTRIC FUNICULAR RAILWAY

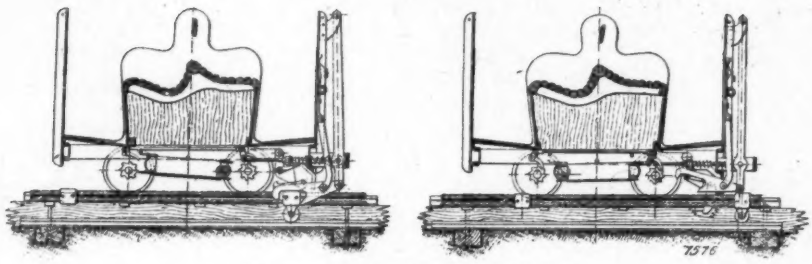


FIG. 4.—NANCY ELECTRIC FUNICULAR RAILWAY.

The cars are transferred from one cable to the other at the end stations by means of travelling platforms (Fig. 3), consisting of endless belts each formed of eighteen steel plates, 2 ft. wide. The belts pass over hexagonal pulleys, driven by a motor with second motion and chain belt, at a speed of 10 in. per second. The motor runs continuously, and is thrown into gear with the driving pulley by a hand lever whenever a car has to be transferred, and is disconnected automatically as soon as the transfer is completed.

The cars (Fig. 4) seat six, and measure 6 ft. in length by 56 in. in width. The cast steel wheels are 12 in. in diameter, keyed on the axles and run on roller bearings; the wheel base is 32 in. The grip engaging with the cable is mounted on a movable bar, which is set in action by hand at the commencement of the trip, and is disconnected automatically at the end. In the event of an accident to the cable, safety brakes stop the movement of the wheels and bring into action catches engaging with iron lugs on the sleepers. These lugs are set about 16 in. apart where the track is steepest, and 6 ft. apart on the lowest gradients.

A New Slide Rule.—Of recent years there has been an increasing tendency amongst engineers to utilise the slide-rule as a means of obviating long and tedious mathematical calculations, but a strong prejudice still survives against the instrument in so far as its old form is concerned. Several attempts have been made to improve the accuracy of the rule without unduly increasing its dimensions, the latest being the model designed by Lt.-Col. F. J. Anderson and manufactured by Messrs. Casella & Co., 11-15, Rochester Row, Westminster. This instrument, the appearance of which is indicated in the illustration (page 465) is simple and compact and is eight times as accurate as the ordinary slide-rule, which, however, it resembles in construction.

It consists of a slide working between two limbs, but the slide has attached to either end an index arm, which serves to give the alignment of the various readings.

A sliding cursor or traveller with a hair-line overlooks all scales. The latter are graduated to ten only, but are split up into a number of parallel lines, four in the case of the upper limb and slide, and eight in the case of the lower limb. At either end of the upper limb (or at the slide which is similarly graduated) there are four columns of black "line-numbers," as follows:—

0	4	8	12
1	5	9	13
2	6	10	14
3	7	11	15

while on the left an additional column of red "line-numbers" as follows:—

— 4
— 3
— 2
— 1

is also provided,

In working, for example, with line-number 0, its graduations are read naturally thus: 1—1.1—1.2—1.3—1.4, &c.; but if recourse be had to, say, line number 4, the above graduations would read as 10—11—12—13—14, &c., while if line number 8 be used the reading would be 100—110—120, &c., and so on. The minus or red line numbers are used for dealing with quantities less than unity. The instrument is used very much in the same way as is the ordinary form, the only complication being that introduced by the line numbers, the understanding of which however, presents no difficulty. In the operation of say, multiplying 2 by 4, the left index of the slide is set to 2 on the upper limb, line number 1; the hair-line of the traveller is then set to 4 on the slide, line number 2, and under the hair line the answer 8 is read on the upper limb, line number 3. The latter is the sum of the line numbers of the two factors.

Squares and square roots are obtained by inspection as the numbers on the slide are the squares of the corresponding numbers (on the same lines) on the lower limb.

By setting the slide immediately over the lower limb, there is thus formed a table of squares and square roots.

With each instrument is supplied a handy

conversion table giving decimal equivalents of twelfths and twenty-sevenths on the face, and of sixty-fourths and eighths on the back. This conversion table renders the instrument usable by engineers, and others, who do not work metrically.

Half an hour's study of the instrument should suffice to familiarise anyone with the method of using it, and we have no hesitation in cordially recommending it.

Explosive Combustion of Hydrocarbons.—The April issue of the *Journal of the Chemical Society* contains a paper* upon the above subject, written by Dr. W. A. Bone, F.R.S., and Dr. J. Drugman, which is of much interest in view of the direct bearing of the subject upon the behaviour of internal combustion engines. In the course of the paper the theory of the preferential combustion of carbon in flames, recently revived by Misteli,† is shown to be untenable as a general theory of hydrocarbon combustion. In former papers, it was proved that the slow combustion of a hydrocarbon involves the initial formation of unstable hydroxylated molecules; and the aim of the present communication is to demonstrate that there is probably no real difference between slow combustion and rapid or "explosive" combustion. The term "explosive combustion" or "explosion" is defined by the authors as a propagation of flame through a combustible mixture under ordinary conditions of inflammation," not as the conditions which exist when an explosion wave ("detonation") is set up.

When only the end results of an explosive combustion are considered, the effects produced by the ignition of an equimolecular mixture of an unsaturated hydrocarbon (an olefine or an acetylene) conform to the requirements of the theory of preferential carbon combustion; for there is no separation of carbon, very little (if any) formation of steam, and the cooled products consist chiefly of carbon monoxide and hydrogen in accordance with the empirical equation—

$$C_nH_{2n} + n/2O_2 = n\,CO + n\,H_2.$$

But if the hydrocarbon is a paraffin, much carbon and steam are always formed; and besides the carbon monoxide and hydrogen, the products contain between 8 and 10 per cent. of methane, fair proportions of unsaturated hydrocarbons (acetylene and ethylene), and of carbon dioxide. Moreover, if an olefine is exploded with less than an equimolecular proportion of oxygen, much water and carbon are formed—the quantity of water increasing as the proportion of oxygen is still further reduced. If a mixture of an olefine with hydrogen and oxygen is prepared in the proportions $C_nH_{2n} + H_2 + n/2O_2$—a mixture containing the same relative amounts of gaseous carbon, hydrogen, and oxygen as exist in an equimolecular mixture of a paraffin with oxygen—the olefine mixture yields no carbon and very little steam when ignited; and its behaviour is thus in striking contrast to that of the paraffin mixture. Again, in many cases of the explosive combustion of hydrocarbons, direct evidence has been obtained of the formation of aldehydes; and the authors have satisfied themselves experimentally that bodies of the aldehyde class cannot possibly be produced at high temperatures by interchanges in the system CO, H_2O, H_2, and CO_2. Hence the theory of the preferential combustion of carbon fails to explain the characteristic behaviour of olefines; whereas the latter becomes intelligible if the initial formation of hydroxylated products is admitted.

In the authors' experiments, combustible mixtures were fired in a sealed-up cylindrical glass bulb having too small a capacity (60 c.c.) to allow an explosion "wave" to be set up. When equimolecular mixtures of ethylene or acetylene with oxygen were ignited, the ratios of the final pressures of the "nitrogen-free" products to the original pressures of the "nitrogen-free" mixtures (p_2/p_1), as well as the composition of the gaseous products, always corresponded with the equations—

$$C_2H_4 + O_2 = 2\,CO + 2\,H_2$$
$$C_2H_2 + O_2 = 2\,CO + H_2$$

except that a little methane was formed. But when a similar mixture of ethane and oxygen was ignited, the ratio p_2/p_1 was only about 1·5 instead of 2·5, a dense cloud of carbon and steam filled the tube, and the products contained nearly 4 per cent. of carbon dioxide, 10 per cent. of methane, appreciable quantities of acetylene and ethylene, as well as carbon monoxide and hydrogen. On rinsing the bulb afterwards with water, the liquid recovered always gave a strong aldehyde reaction when submitted to Schiff's test. The ratio H_2/O_2 in the condensed products was generally somewhat over 2—a circumstance that may perhaps be connected with the formation of acetaldehyde. Large differences in the original pressures under which the mixtures were held in the bulb made no appreciable difference in the results of igniting ethylene; but when ethane was tested, the unsaturated hydrocarbons and the steam tended to increase inversely with the original pressure. The authors estimate that between 12·5 and 16·5 per cent. of the carbon in the ethane, and from one-third to two-fifths of the original oxygen were not accounted for in the gaseous products. Steam does not seem to be present in combustion products of ethane and absent from those of ethylene owing to the much lower flame temperature of the latter, because the total evolution of heat is greater in the first case than in the second.

When higher paraffins (propane and *n*-butane) were ignited in the same manner, similar phenomena were observed as when ethane was under examination. The gaseous products

* Abstracted in the *Journal of Gas Lighting*.
† See *Journal of Gas Lighting*, vol. xciii., p. 291.

contained 8 or 9 per cent. of methane, 3 to 5 per cent. of unsaturated hydrocarbons, and about 4 per cent. of carbon dioxide. On testing methane itself with an equal volume of oxygen, the products were found to contain about 1 per cent. of methane and 5·7 to 6·8 per cent. of carbon dioxide; p_2/p_1 varying only between 1·02 and 1·03, though p_1 varied from 335 to 651 mm. The proportion of the original oxygen recovered in the steam was sensibly constant at 43·5 to 44·8 per cent. With higher unsaturated hydrocarbons, the results differed somewhat, according to the proportions of oxygen employed. From mixtures of propylene and trimethylene with one-and-a-half times their volume of oxygen, no carbon separated; but in some cases a little dew was to be seen. Equimolecular mixtures yielded free carbon and a quantity of water representing 25 per cent. of the original oxygen. The average ratio H_2/O_2 was nearly 2·6, suggesting the formation of something besides water in the condensates. When a mixture of propylene corresponding with the formula $C_3H_6 + 1\frac{1}{2}O_2$ was fired, only 21 per cent. of the original oxygen was discovered in the condensed products, and the ratio H_2/O_2 was exactly 2. On exploding *n*-butylene with twice its volume of oxygen, the ratio p_2/p_1 was 2·43, as compared with 2·2 in the case of *iso*butylene. No carbon and only a visible amount of dew were formed. With one-and-a-half volumes of oxygen, carbon and much water were produced, and the aldehyde reaction was distinct. Between 24 and 28 per cent. of the original oxygen appeared in the condensates.

When a mixture of $C_2H_6 + O_2$ was exploded, much carbon and water were produced, and over 27 per cent. of the original hydrogen was found in the condensed products. When an arithmetically identical mixture of $C_2H_4 + H_2 + O_2$ was exploded, no carbon was liberated; only sufficient steam was formed to be visible; and, according to the initial pressure, from 5 to 8 per cent. of the original hydrogen was in the condensed products. When the mixture was composed of $C_2H_2 + 2H_2 + O_2$, neither carbon nor steam was to be seen, and the proportion of condensable hydrogen was negligibly small. Hence hydrocarbons are certainly not decomposed into their elements before combustion. At the temperatures prevailing in ordinary flames, they exhibit an enormously greater affinity for oxygen than does either hydrogen or carbon. Acetylene differs from all the other unsaturated hydrocarbons examined inasmuch as there is little or no formation of steam when the oxygen is reduced below an equimolecular proportion. Part of the acetylene burns to carbon monoxide and hydrogen, and the remainder is resolved into carbon and hydrogen *plus* a little methane. Indeed, it would appear that something tantamount to direct conversion of the C_2H_2 into $C_2H_2O_2$ occurs in flames.

Although, as has already been mentioned, evidence of the formation of aldehydes is sometimes to be obtained directly, or by withdrawing some of the interconal gas from the flame of ethane or ethylene burning in a modified Smithells separator, it is much easier to demonstrate the occurrence of aldehyde in a flame of air or oxygen burning in coal gas or in a hydrocarbon such as ethane or ethylene. The authors have designed a very convenient form of apparatus for carrying out the test, which they describe in their original communication.

The foregoing results seem to prove that a hydrocarbon is not decomposed to any great extent in a flame, except when the supply of oxygen is severely limited; it is certainly not resolved into its elements. Probably the "oxygenated" hydrocarbon is the substance that decomposes. The behaviour of methane in a flame is best explained thus:

$$CH_4 \quad CH_3{\cdot}OH \longrightarrow CH_2(OH)_2 \longrightarrow CH_2O + H_2O,$$

the formaldehyde (CH_2O) decomposing into $CO + H_2$ at the high temperature obtaining. In the case of ethylene, so much water is produced when the mixture $3C_2H_4 + 2O_2$ is exploded, that it seems more likely that a monohydroxy derivative, $CH_2{:}CH{\cdot}OH$, is produced than such a molecule as

The large quantity of water formed in the explosions of $3C_2H_4 + 2O_2$, $C_3H_6 + O_2$, and $C_4H_8 + 3O_2$, points to the production of monohydroxy, rather than dihydroxy, derivatives; and the same thing is indicated by the phenomena of low temperature combustion, where the rate of oxidation is greatly retarded by an excess of oxygen over and above an equimolecular proportion, but it is hardly, if at all, retarded by a corresponding excess of hydro-carbon. In certain conditions (*e.g.* detonation) the dihydroxy-derivative may be produced direct. Possibly this occurs with acetylene.

The suggestion that oxygen acts directly upon a hydrocarbon without the intervention of steam is opposed to the view held by Armstrong, who fails to see why, if this is the truth, dihydroxy-derivatives should not be formed at once. But it may be that in flames the oxygen does not exist entirely in the molecular condition; and moreover the difficulty urged does not seem greater than that involved in the idea that the formation of a hydroderivative always requires the simultaneous conjugation of hydro-carbon, water and oxygen. At present, it does not appear that the presence of water, is necessary for hydrocarbon combustion.

On the whole, then, in an adequate supply of oxygen, the combustion of an olefine (*e.g.* propylene) involves successive eliminations of

formaldehyde, which immediately decomposes into carbon monoxide and hydrogen, thus:

$$CH_3 \cdot CH : CH_2 \xrightarrow{(1)} CH_3 \cdot CH : CH \cdot CH \longrightarrow$$
$$CH_2 : CH_2 \xrightarrow{(2)} + CH_2O \longrightarrow$$
$$\overbrace{CO + H_2}$$
$$CH_2 : CH \cdot OH \xrightarrow{(3)} \longrightarrow CH(OH) : CH \cdot OH \xrightarrow{(4)}$$
$$\overbrace{2\,CH_2O = 2\,CO + 2\,H_2}$$

With only two-thirds of the above amount of oxygen, the process would stop at stage 3, and the product would break down into acetylene and water, or into carbon, hydrogen and water. Since acetylene yields much methane when decomposed by heat, the presence of as much as 10 per cent. of methane in the explosion products of $C_2H_6 + O_2$ is explained.

A paraffin may be considered to burn in either two ways: (1) As at the lower temperature, aldehyde and steam being formed early—

$$CH_3 \cdot CH_2 \cdot CH_3 \longrightarrow CH_3 \cdot CH_2 \cdot CH_2 \cdot OH \longrightarrow$$
$$CH_3 \cdot CH_2 \cdot CH(OH)_2$$
$$\overbrace{CH_3 \cdot CH_2 \cdot CHO + H_2O}$$

the aldehyde then decomposing to yield carbon monoxide and the lower paraffin, and the whole process being repeated until at length the acetaldehyde breaks down into carbon, hydrogen, methane, and carbon monoxide. (2) According to the alternative hypothesis, the primary oxidation product $C_nH_{2n} + 1 \cdot OH$ may decompose into $C_nH_{2n} + H_2O$, and the olefine may then continue the process in its own peculiar way.

Jarring in Steam Pipes.*—There is nothing more noticeable in the operation of most steam plants, even in those arranged according to approved methods, than the tendency to vibrate of the pipes conveying steam to a working engine. These vibrations are not produced by any movement of the engine itself, but are due to an entirely different cause, the effect produced by the peculiar motion of the steam itself within the pipe, caused by the intermittent character of the discharge of steam into the engine cylinder. A steam gauge attached to the main supply pipe of the engine, if wide open, will show so much fluctuation, occurring in unison with the reciprocations of the engine, as to endanger the working parts of the gauge. An indicator applied to a steam pipe will show a series of undulations, as it were, in the pressure, also in unison with the movement of the engine. The steam-pipe diagram, in a case where there are numerous bends between the boiler and the engine, will reveal a variation of pressure amounting possibly to 10 lb. for every revolution of the engine, although the supply pipe may be what is considered ample in size. These instruments show that the movement of steam occurs by a series of pulsations, the current being arrested every time the cut-off valve is shut and set in motion again whenever the valve is open. The effect produced by this intermittent current is to cause the pipe to rebound wherever the direction of the current is changed, as occurs where the steam passes through an elbow. A force is thus applied in the direction of its length on every section of the pipe, and the pipe must be braced at every angle in order to withstand it. The trouble is most active where slow-speed engines are in use, the pulsations occurring here at comparatively long intervals of time.

The remedy is to place near the engine a reservoir into which the steam is first supplied as it is delivered from the boiler, and feed the engine with a pipe leading from this reservoir. The larger the reservoir compared with the volume of the cylinder, the better is the result. With this arrangement the steam is first drawn from the reservoir, and the excessive fluctuations of pressure due to the intermittent supply to the engine are confined to the pipe which leads from the reservoir to the engine. There is a sufficient amount of steam stored in the reservoir to prevent much fluctuation of pressure there, and the flow of steam into it from the boilers occurs in an approximately continuous current, where before it was intermittent. This method of preventing vibrations of pipes has been growing in favour slowly, and where it has been applied there is a most satisfactory absence of the jarring.

* *Engineering Record*, 28th April, 1906.

Metallurgical Progress.

By PERCY LONGMUIR.

The May Meeting of the Iron and Steel Institute.

Compression of Steel Ingots in the Mould.—Last month we noted a paper by Mr. N. Lilienberg, in which to some extent Illingworth's process for the production of sound ingots was indicated. In the present paper Mr. A. J. Capron deals with improvements effected by Messrs. Robinson and Roger, which have rendered the process applicable to ingots of considerable weight. The ingot moulds are placed inside the press, the latter practically forming a casting pit; each mould may have a loose bottom plate, or the whole of the moulds may stand on one common plate for bottom casting. The construction of the press is illustrated in Figs. 1 and 2, the former representing a press of 8,000 tons, and the latter one of 5,000 tons. The ingot moulds of Fig. 1 are divided in the centre, and a loose packing piece of any convenient shape placed between the half moulds, or the sides of the mould may be made removable according to the purpose for which the ingots are intended. The moulds are cast simultaneously, either by means of a trough with a separate runner for each mould, or in groups by means of bottom running. On solidification of the crust, the packing pieces are withdrawn and pressing commenced, sufficient pressure being applied to follow up the contraction taking place. The pressure is gradually increased during solidification until a final pressure of about 2 tons per square inch on the surface is reached; this is maintained for a short time, ensuring absolute solidity in the ingot.

Fig. 2 shows another type of ingot mould, the sides of which are grooved sufficiently deep to allow for the requisite compression. The press holds the moulds in position during casting, and there being no packing pieces to move, can at once follow up the contraction until the maximum pressure is reached. The various parts of the press are as follows:—*AA*, pressing cylinders; *BB*, pushback cylinders; *CC*, tension bars; *DD*, steel straps in tension; *EE*, cast iron packing blocks in compression. The press is worked by direct high-pressure pumps at about 3 tons per square inch, whilst the gradual increase of pressure required is regulated by a bye pass valve.

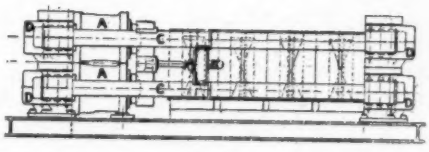
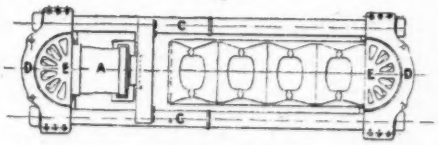


Fig 1



8,000 TONS HYDRAULIC PRESS FOR FLUID COMPRESSION OF STEEL.

Thirty horse-power is sufficient for an 8,000 ton press dealing with a cast of 60 tons of steel. The process has been in daily use in Messrs. Jessops' works for over two years, and in dealing with over 1,500 ingots, not a single failure has been met. Equally good results are obtained from open hearth steel, and Messrs. Jessops are now putting down a 7,200 ton press for dealing with ingots up to 20 tons in weight. Finally, the

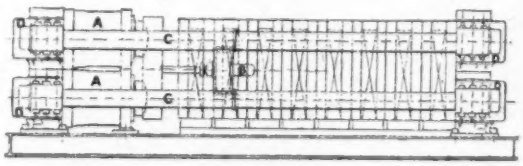
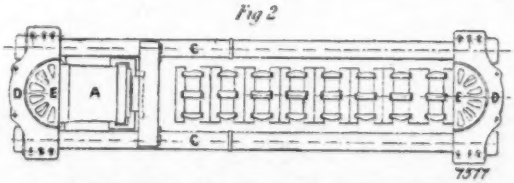


Fig 2



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5,000 TONS HYDRAULIC PRESS FOR FLUID COMPRESSION OF STEEL.

author summarises the advantages of this system as :—(1) An absolutely sound ingot is ensured free from any pipe or cavity, so that the whole of the ingot can be used, and practically no waste incurred. (2) Being able to watch the top of the ingot and get rid of the liquated portions, a great improvement in the quality of the steel can be obtained. (3) The ingots are cast in place, and have not to be moved until the completion of the compression. (4) The simplicity and cheapness of the plant, and the ease with which it can be worked by unskilled labour. (5) Owing to the way the moulds are divided the ingots are parallel, which falicitates rolling. Further than these, the advantage may be taken of the fact that the compressed ingot is at least equal to steel that has been forged or cogged, and consequently the cost of the subsequent processes of manufacture may in many cases be greatly reduced by the adoption of this system.

Preliminary Note on the Influence of Manganese on Iron.—Professor Arnold and Mr. F. K. Knowles at the outset emphasise the fact that the exact influence of nearly pure manganese on nearly pure iron is still unknown. Apart from this, many discrepancies are met with in published tests, of which the following represent typical instances :—

Guillet.			Hadfield.		
per cent.			per cent.		
Carbon ... 0·058	Max Stress ...	27·7 tons sq in.	Carbon ... 0·40	Max Stress ...	38·0 tons sq. in.
Manganese 4·200	Elongation ...	21·5 per cent. on 8 in.	Manganese 3·89	Elongation ...	0·5 per cent. on 8 in.
Silicon ... 0·304	Reduction of area	76·5 per cent.	Silicon ... 0·09	Reduction of area	0·0 per cent.

Dr. Guillet attributes this discrepancy to the high carbon content of Mr. Hadfield's alloy, but the authors by investigation have confirmed Mr. Hadfield's conclusion as to the brittleness of both iron and steel containing about 4 per cent. manganese. For example an alloy containing

Carbon	0·050 per cent.
Manganese	3·728 ,,
Silicon	0·050 ,,

registered the following mechanical tests :—

Max Stress Tons per sq. in.	Elongation per cent. on 2 in.	Reduction of area per cent.
57·8	1·0	1·7

Turning to the preparation of the alloys, Swedish bar iron containing 99·8 per cent. metallic iron was melted in the author's special research crucibles. These crucibles are made from the following mixture :—

Unburnt Stourbridge fire clay ...	45 per cent.
Unburnt Derby fire clay	21 ,,
Unburnt Stannington fire clay ...	21 ,,
Unburnt Cornish china clay ...	10 ,,
Low sulphur coke dust	3 ,,

The metallic manganese was in each case separately melted in a special crucible made from the following mixture :—

Crystalline magnesia fused in electric furnace	15 lb.
Unburnt Stourbridge fire clay	12 oz.
Water containing by volume 12½ per cent. of fluid silicate of soda	650 cc.

This crucible fitted inside an ordinary plumbago crucible.

Melting conditions were arranged that the iron and manganese could be drawn together, the contents of the crucibles mixed, and after standing for half a minute to allow for transfusion were cast into 2-inch square ingots weighing about 35 lbs. each.

These ingots were cogged down to 1¼ inch square and rolled down to $\frac{15}{16}$ inch round. On examining the finished bars by taking drillings from the middle and each end a distant liquation of manganese was found. Thus three typical alloys showed

Experimental Ingot.	Manganese—per cent. in rolled bars.		
No.	One end.	Middle.	Other end.
977	3·07	3·48	3·42
944	16·60	13·85	11·96
966	26·53	28·24	35·14

This will necessitate each separate test piece being assayed for manganese at the exact point of fracture, but will possess the advantage of yielding a wide range of percentage which under other circumstances could only be obtained from a very large series of ingots. When the research is completed it is possible, though hardly probable, that some of these costly alloys may prove of practical importance. It is however certain that theoretically in connection with the fundamental physics of steel the data obtained will be of supreme importance.

The Effect of Copper in Steel.—Mr. F. H. Wigham records a series of experiments conducted under works conditions in order to ascertain the effect of copper on steel, Notwithstanding the fact that various authorities have shown that copper in reasonable amount has no deleterious effect, much prejudice still exists against the presence of this element in steel. A large number of alloys have been made by adding varying amounts of copper to steel made by the open hearth process. The method of alloying was to pour the steel into

Sample.	Copper per cent.	Torsion in 8 in.	Bends of 180° over radius of 10 mm.	Elongation per cent. on 20 in.	Breaking strain in lbs.	Tensile strength tons per sq. in.
A 1	0·192	18	4	18·0	4200	53·2
A 2	0·422	18	4	15·2	3900	47·5
A 3	0·604	12	4	15·2	4400	54·7
A 4	0·850	8	3	11·6	4450	54·2
A 5	1·024	4	2	12·6	4800	58·4
Standard	0·028	12	4	18·0	4020	50·9

a ladle containing the requisite amount of ingot copper. Attempts were made to add the copper to the steel as it ran into the moulds, but imperfect mixture resulted, although good results were obtained with copper below 1 per cent. by the addition of 0·02 per cent. aluminium. The ingots were hammered to billets and worked down into rods without difficulty. Tests of the rods showed that samples A_1, A_2, and A_3 were quite satisfactory in bending and in elongation, but A_4 and A_5 were very hard and brittle. After annealing the rods under identical conditions the above results were obtained.

The standard sample contains 0·50 per cent. carbon; 0·46 manganese with low amounts of silicon, sulphur and phosphorus and the other alloys of the series approximate very closely to these figures. Therefore in studying the effect of the variable element copper it will be noted that up to 0·604 per cent. the bends agree with that of the standard, whilst torsion tests in the first two cases are very much better than the standard. The rods were drawn down into wire and the annexed results obtained representing untempered steel.

From tempered samples very similar results were recorded, and the following results represent samples drawn to finish at an approximate breaking strain of 85 tons per square inch, with the diameter of 0·098 inches after being tempered in the 5 B.W.G.

Sample.	Torsion in 8 ins.	Bends.	Breaking Strain in lbs.	Elongation per cent. with 20 inch test pieces.	Tensile Strength Tons per sq. in.
A 1	34	12	1,482	2·8	87·7
A 2	16	12	1,520	2·6	90·0
A 3	12	6	1,580	2·1	93·4
A 4	7	6	1,580	1·2	93·4
A 5	8	4	1,620	1·2	95·9
Standard	32	12	1,470	2·8	86·3

Other series of tests are given, and in conclusion the author notes that—(1) Copper is difficult to alloy with steel so as to obtain a homogeneous mass containing over 2 per cent. even with the addition of aluminium. (2) Steel alloyed with copper in the pure form with

A 1.

Gauge in inches.	Bends of 180° over a radius of 10 mm.	Torsion in 8 inches.	Breaking Strain in lbs.	Tensile Strength. Tons per square inch.
0·128	8	62	1,270	44·1
0·117	8	52	1,080	45·0
0·106	8	62	1,000	50·7
0·094	8	72	760	40·9
0·085	10	23	680	53·5
0·076	12	20	600	59·4
A 2.				
0·128	9	40	1,220	42·3
0·117	7	32	1,220	50·8
0·107	8	13	1,120	55·7
0·092	9	14	880	59·0
0·082	7	10	780	66·1
0·073	8	11	670	72·3
A 3.				
0·128	7	42	1,310	45·5
0·115	8	47	1,180	50·6
0·104	7	32	980	51·6
0·094	7	19	900	58·0
0·080	7	12	720	63·7
0·073	8	10	630	67·0
A 4.				
0·127	8	59	1,240	43·6
0·115	8	60	1,130	48·5
0·105	9	63	1,000	51·5
0·092	8	18	870	58·3
0·082	7	14	700	59·3
0·073	10	15	610	64·9
A 5.				
0·128	9	56	1,220	42·3
0·115	8	49	1,200	51·5
0·106	8	22	1,040	52·7
0·092	8	16	840	56·3
0·082	9	11	700	59·3
0·074	9	7	630	65·6
STANDARD.				
0·128	8	62	1,280	44·4
0·115	8	63	1,130	48·5
0·105	9	61	1,010	52·0
0·091	8	42	890	60·9
0·083	8	34	730	60·3
0·074	9	34	640	66·6

the addition of aluminium is not so perfectly mixed as it is when it is added to the charge of steel in the furnace, and more copper could safely be employed provided it was in the metal before it was completely converted into steel. (3) In steel containing 0·5 per cent. or more of carbon it is not of practical value to use more than 0·6 per cent. of copper. (4) Alloys up to 0·25 per cent. of copper with high carbon (say 0·70 per cent.) give, with or without a high percentage of manganese, a good quality of wire. Finally it may be considered as proved that copper to the extent of 0·25 per cent. is no disadvantage in the manufacture of the best classes of steel wire.

Brittleness and Blisters in thin Sheet Steels.—This research by Mr. E. F. Law deals with a matter of supreme importance to certain sections of the steel industry. At the outset the author states:—

"The defect which gives rise to blistered sheets must be distinguished from that which gives rise to brittle sheets although the two may and often do occur in the same sheet." An examination of many sheets showed that the brittle and blistered sheets were invariably of less pure steel than tough sheets, a result fully confirmed by an examination of the original steel from which the sheets had been rolled. These steels showed marked segregation and were invariably very impure, the impurities being sulphur, phosphorus, and another constituent whose identity had not been definitely settled, but which the author believes to be oxide. This impurity is always associated with blistered sheets. A series of results are given showing the effect of the quality of the steel on the finished sheet, the chief point of which lies in the low sulphur content of the tough sheets, 0·056 as against 0·08 per cent. in the brittle sheets. Taking the influence of impurity in detail the author in the first place considers a steel containing large quantities of oxide such as the product of an overblown Bessemer charge. Whilst a chemical analysis of such a steel would not reveal anything abnormal, a microscopical examination would at once show the presence of oxide. In the pickling bath large volumes of hydrogen are evolved which, assisted by the high temperature of the pickling bath, reduces the oxide in the steel with the formation of water vapour. The volume of the molecule of water is, however, much greater than that of hydrogen, and therefore is incapable of passing out of the sheet. Further, the volume occupied by the water vapour is greater than that of the original oxide, and the internal pressure thus produced is sufficient to cause an incipient blister which increases in size owing to the expansion of the water vapour when the sheet is subsequently annealed. During annealing, however, the reaction is reversed, for at a red heat water vapour is again decomposed with the formation of oxide and liberation of hydrogen.

Sulphur and phosphorus are considered together, and the fact that these elements segregate towards the centre and top of an ingot is shown. These segregations occur more or less spherically, therefore work on the ingot results in flattening and elongation of the segregated areas rich in sulphur and phosphorus. This leads to the formation of lines or "ghosts" rich in sulphur and phosphorus, as may be proved by analysis. Thus a bar showing marked segregation gave the following results on analysing drillings taken along the bar in the direction of rolling and through the bar.

—	Through the bar.	Along the bar.
Carbon	0·117	0·120
Sulphur	0·080	0·104
Phosphorus... ...	0·068	0·087

Microscopical studies of this aspect lead to the conclusion that a thin sheet rolled from a bar showing ghosts will consist of laminæ of ductile steel separated by laminæ of less ductile and highly-phosphoric steel together with laminæ of manganese sulphide. When such a sheet is subjected to bending the ductile material tends to slip over the less ductile material and the sheet fractures. If the defect is due to this cause, brittleness should not be uniform throughout the sheet, and, as a matter of fact, this is found to be the case. Finally the results of the investigation would seem to show that: (1) oxidised steel will give rise to blistered sheets, and that this defect is more liable to occur with Bessemer than with open hearth steel; (2) steel high in sulphur and phosphorus will cause brittleness in sheets, especially if the sheets are rolled from large and slowly-cooled ingots in which the maximum segregation has taken place.

The Relation between Type of Fracture and Microstructure of Steel Test Pieces.—This is an interesting subject, and Mr. C. O. Bannister presents a series of comparisons which go far towards proving the fact that the fracture of a tensile test piece is a good index of quality quite apart from the numerical result obtained. The types of fracture include (1) cup, (2) laminated, (3) irregular, (4) crystalline, and (5) slip or oblique. The structures of a number of test pieces giving fractures of the foregoing types have been examined and the results may be summarised as follows:—Cup fractures are obtained with homogeneous minutely crystalline or granular steel, which is practically free from flaws of slag and manganese sulphide. The more homogeneous the steels the deeper will be the cups obtained. Steels giving laminated fractures always contain slag lines or minute "ghost lines" running in parallel straight lines across the specimen in exactly the same direction in which the laminations

are found. In the slag lines the elongated patches consist of manganese silicate usually accompanied with manganese sulphide. Steels giving very irregular fractures are generally inferior in quality, and are made up of irregular patches of pearlite and ferrite nearly always accompanied by slag lines or more or less developed "ghost lines" which run at different angles or are curved. At least two varieties of ghost lines occur in steels in one of which there is a segregation of carbon, sulphur and phosphorus accompanied by a considerable segregation of silicon and manganese, whilst in other cases there is only a small amount of silicon and manganese in excess. Crystalline fractures show a distinct relationship between the size of the crystals and the micro-composition of the steel, and when slag and manganese sulphide patches are present they are arranged in the ferrite bands around the pearlite. Oblique fractures are frequently varieties of laminated fractures, and where laminations are entirely absent there are often indications that rupture occurs in the direction in which the ferrite bands are best developed. Although laminated fractures are always associated with slag lines or ghosts, yet coarsely crystalline steels containing ghosts do not always give laminated fractures. Finally it is noted that the prevalence of manganese sulphide and manganese silicate in commercial steels fully justifies their being classed as important constituents.

Volume and Temperature Changes during the Cooling of Cast Iron.—Professor Turner has, for the purpose of this research, devised an apparatus of simple construction but of very high value and capable of application as a method of investigating many foundry problems. Practically the apparatus consists of three portions, (*a*) the mould and test bar, (*b*) an arrangement for indicating changes of length in the bar, and (*c*) a pyrometer. The form of test piece and method of working are shown in Fig. 3. The T form of the test piece ensures that one end of the bar is stationary; this is further assured by the steel pin *A* which passes through the mould and is cramped in position outside the box. At the other end a thin fin of sand is left sufficient to retain the fluid metal in the mould but not enough to interfere with the free movement of the solid bar. A pin is passed horizontally through this fin and continuous with the centre of the bar. On casting, this pin is surrounded with metal and becomes firmly embedded in the bar, but it is free to move with the bar in an horizontal direction, and its outer end is attached to an indicating apparatus or extensiometer. The latter consists of a brass pointer 28 in. long, which is supported so that it swings freely, but is kept at rest in a vertical position by means of a weight except when deflected during the progress of an observation. In the apparatus employed the actual movement was multiplied about forty fold, but this is a detail which may be varied at will. Temperature indications were obtained from a "Le Chatelier" thermo-couple placed bare in the

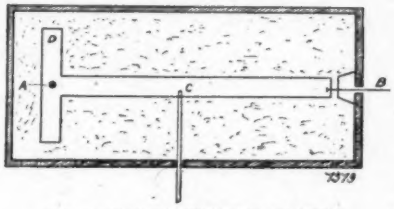


FIG. 3.—PLAN OF LOWER HALF OF MOULD.
A. Fixed vertical pin. *B*. Movable horizontal bar.
C. Thermo-couple. *D*. Position of gate.

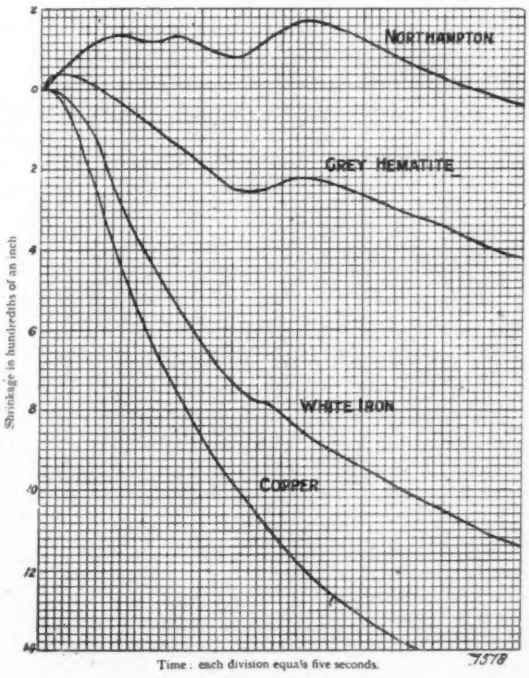


FIG. 4.—TYPES OF CONTRACTION CURVES.

mould so as to give actual contact, and the scale divisions were read by eye.

The types of contraction curves obtained admit of division into several classes, as for example those shown in Fig. 4. Here it will be noted that in the case of copper there is no arrest in the decrease of volume as the metal cools. A second type of curve offers indications of one retardation during contraction, which may or may not lead to an actual expansion of which white iron is typical. The third type indicates that two arrests have occurred in the rate of contraction; thus grey hematite gives two marked expansions, one occurring immediately after the metal has become sufficiently solid to cause the indicator to move and the other after an interval of nearly three minutes, when a half-inch bar is employed. The top curve of Fig. 4 shows a type in which three distinct arrests are found. A very grey phosphoric iron gives the most characteristic curve of this type. The second expansion is relatively small in amount, and though the first expansion is large it is not so very pronounced as the third; while as a result of the three taken together, no less than four minutes and thirty-five seconds have elapsed with a ½-in. bar before it has again reached the original size of the mould, after which contraction proceeds regularly to the atmospheric temperature. Some characteristic shrinkage and cooling curves of varieties of cast iron are given, and lead to an examination of the influence of composition. Briefly this may be summarised as follows:—

	Iron containing		
	Carbon only.	Carbon and Silicon.	Carbon Phosphorus and Silicon.
First arrest ...	Almost absent.	At 1135°	At 1060°
Second arrest...	Absent.	Absent.	At 900°
Third arrest ...	At 665°	At 695°	At 730°

Naturally the type of curve varies with the type of iron, as illustrated in Fig. 4, and the above table is not intended to cover the whole range of foundry irons. Considerable interest centres round the third arrest. Thus in the absence of silicon the change of volume at a temperature of 665° is small, with intermediate silicon the expansion becomes marked, and occurs at about 695° C., with about 4 per cent. silicon the expansion becomes very large indeed and takes place at about 730° C. If it be assumed that coarse-grained or flaky graphite separates during the first expansion, as there is every reason to believe, then the question arises whether the third expansion is not due to the separation of temper carbon, from, or instead of, pearlite under the influence of silicon. If temper carbon is not separated at the third retardation, or at a temperature of about 700° C., it is difficult to account for the marked expansion which occurs. In this respect the increase of volume induced in white iron by annealing is worthy of note, an increase doubtless due to the separation of temper carbon.

Influence of Silicon, Phosphorus, Manganese and Aluminium on Chill in Cast Iron.—The greater part of Mr. Adamson's paper is devoted to "conclusions" which do not appear to have a very direct connection with the experiments. However, the latter appear to show that the depth of chill is primarily dependent upon the percentage of combined carbon and the casting temperature as illustrated in the following table:—

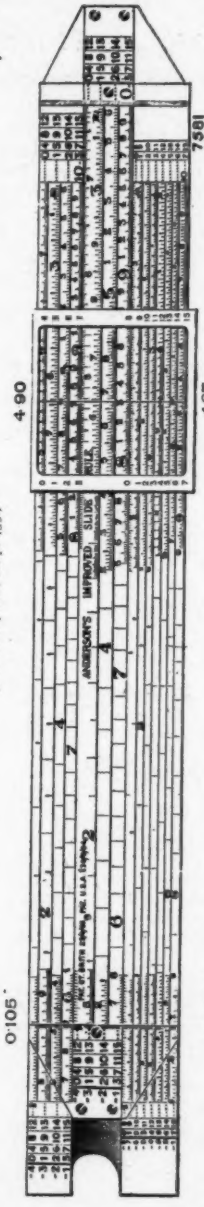
Combined Carbon.	Temperature.	Chill.	Temperature.	Chill.
0·67	1240°C	1/16	1187°	1/16
0·73	1222	1/8	1187	1/8
0·76	1258	1/8	1208	1/8
0·85	1258	1/8	1160	1/8
0·88	1215	1/4	1187	1/4
0·88	1258	1	1236	1/8
0·74	1298	1/8	1215	1/2
0·90	1282	1½	1194	1
1·65	1274	1½	1229	1¾

From other tables we gather that an increase of silicon from 0·74 to 1·40 per cent. results in a decrease in the depth of chill. An increase of phosphorus from 0·303 to 1·075 per cent. also diminishes the depth of chill, whilst an increase in manganese of from 0·613 to 3·25 per cent. gives an increase in the depth of chill of from ⅞ in. to 1¼ in. Increments of aluminium from 0· to 0·4 per cent. result in a successive decrease in the depth of chill.

Use of Oxygen in removing Blast Furnace Obstructions.—The Chevalier C. de Schwarz shows that a choked tap hole or tuyere can be readily opened by the aid of compressed oxygen. The method is as follows:—Compressed hydrogen and oxygen are contained in two separate steel flasks, each provided with a suitable regulating valve. The burner consists of an outer and inner tube, the former supplying hydrogen and the latter oxygen.

The iron to be burned through is first heated by the oxyhydrogen flame, the pressure of both gases being low at first, but gradually increased until a hot flame results and the spot on which it impinges is heated to a white heat. The pressure of the oxygen is then raised to such an extent that the iron commences to burn. On reaching this stage the pressure of the oxygen is further raised to thirty atmospheres or more, and the supply of hydrogen cut off. From thence onwards iron replaces hydrogen as a combustible and a degree of heat is developed which far surpasses that produced by means of oxyhydrogen gas. The high pressure of the oxygen serves to force out all molten iron, thus keeping the hole burnt through, throughout the whole

of the operation. It can be shown that a solid block of cold iron or steel, say 16 in. thick, can in this way be pierced within one or two minutes. The process has been successfully applied for opening blast or slag tuyeres, and tap-holes of open-hearth furnaces when choked by iron. Other examples of its use are found in the removal of feeding heads or runners from steel castings and in piercing hard material such as armour plate. Whilst a plate of 9 in. in thickness would require two or three hours if drilled in the ordinary way, by the aid of compressed oxygen this work can be done within fifteen to twenty seconds.



(*For description, see p.* 455.)

Multiply ·0105 × 467.
(*a*) Set left Index to ·0105 on upper limb, line No. 8. (*b*) Set Traveller to 467 on slide, line No. 10.
(*c*) Under Traveller on upper limb read answer 4·90, line No. 2.

BOOK NOTICES.

Modern Electricity: a Practical Working Encyclopedia and Manual of Theories, Principles and Application. By JAMES HENRY, M.E., Professor of Electrical Engineering, and KAREL J. HORA, M.Sc., Expert Electrical Engineer, 1905. (London: Hodder and Stoughton). Price, 5s. net.

The authors of this work have attempted to crowd into a book, small enough to go in one's pocket, a discussion of the theoretical principles of electricity and of all the different fields in which that agent is now applied, and it is not surprising that their attempt should not have been crowned with success. We think it unfortunate that the authors should have been so ambitious in their aim, for had they been content to make their work purely an "electrical engineer's pocket-book," increasing for this purpose the number of practical formulas for the solution of problems and cutting out most of the purely theoretical matter, they might have served a useful purpose. Far from adopting this line, however, they claim in their preface that the volume has been prepared "with a view of meeting every emergency that might confront the electrical engineer and inventor," and that every effort has been made to amplify the information usually given in practical textbooks, "without sacrificing its clearness or accuracy, so that every apprentice and artisan will be able to gain a complete knowledge of the fundamental principles and applications of electricity. . . . The work will be found eminently practical, scientific and accurate." There is no excess of modesty here, but we do not complain of that. If a man feels convinced that he has accomplished a great work, he has a right, if he thinks it advisable to exercise it, to proclaim his success to the world, but he must be prepared to find his work judged by the standard which he claims for it, and in the present case we at least cannot find that the authors are justified in their claim.

To begin with the theoretical portions, these are at the best but scanty and unsatisfactory, but, worse than that, the authors are not always accurate. Take, for example, the sections under the heading "Condenser-Electrical Capacity." This very title is an instance of putting the cart before the horse, but it is intentional, for the authors actually begin to describe and discuss the condenser before they have ever touched upon the principle of capacity, and their discussion leads them to this extraordinary definition:—"The capacity of a condenser equals the combined capacity of the two plates." Will any one tell us what is meant by the capacity of *one* plate of a condenser. Although the authors are described as in one case a Professor of Electrical Engineering (place where, not mentioned) and in the other an Expert Electrical Engineer, they do not seem to have realised that in speaking of the capacity of a condenser, it is the capacity of the *field* that is the main consideration, and that the plates are only important as determining by their position and area the boundaries and extent of that field. It is true that they follow up the definition quoted by a statement that the capacity of condensers varies inversely as the thickness of the dielectric and directly as the "dielectric capacity of the dielectric"—whatever that phrase may mean—but how can a student connect such a statement with the definition preceding it? On a later page we read: "It is evident that any two conductors lying close together, unless separated by a well-insulating dielectric, will increase their capacity, acting inductively on each other and modifying their relative potentials." This is dangerous nonsense, and readers will note that here again we have conductors treated as having an inherent capacity of their own, capable of being altered at will, whereas it is the alteration in the electrostatic field in each case that causes the capacity of that *field* to increase or diminish. In another part of the book we read that "kinetic energy does not enter into the question of electricity."

We might point out other flaws in the theoretical portions of the book, but we will only say that where these are correct, they are insufficient to provide real instruction for the student. The greater part of the volume is devoted to the working out of diverse practical problems by means of formulas, which, in most cases, the student must accept without knowing how they are obtained. We cannot therefore agree with the statement in the preface that "each formula is explained in the clearest manner possible." We do not recommend this work to any earnest student desiring to understand theoretical principles.

Cost Accounts: An Explanation of Principles and a Guide to Practice. By L. WHITTEM HAWKINS, A.C.A. 1905. (London: Gee & Co). Price 5s. net.

While the importance of accurate cost accounts is too obvious for comment, it is not certain that the means adopted by manufarturers are always the best and most economical for arriving at the desired end. In this work the author explains in general terms the principles underlying industrial accounts and illustrates his exposition by examples. In Part I the elements constituting cost are considered in turn, first in connection with the cost books and then in regard to the general account books of the establishment. The relationship that should exist between the two sets of books is made clear by means of a diagram, which also indicates the connection between the different books of each series. In Part II. we have suggestions showing how the various parts of an account system may be elaborated

with the objects of arriving at greater accuracy, and of furnishing information for future guidance in the conduct of business. In this volume Mr. Hawkins sets forth a sound and practicable system of book-keeping which is generally suitable for engineers, contractors and others engaged in manufacturing processes. It is probable that modifications in points of detail will be found necessary for the purpose of adapting the system to the requirements of individual manufactories. That is inevitable, but we are sure that the system proposed may be adopted with advantage in many old-established works where methods of keeping cost and other accounts have grown up without the skilful pruning and judicious co-ordination which alone can yield satisfactory and economical results.

The Application of Graphic and Other Methods to the Design of Structures. Second Edition. By WILLIAM W. F. PULLEN, Wh. Sc., M. I. Mech.E., Assoc.M.Inst.C.E. 1905. (The Technical Publishing Company Ltd: Manchester). Price 5s. net.

When compiling the first edition of this excellent work the object of the author was to emphasise the great convenience of graphic methods for the determination of numerical results required by practising engineers. The treatise includes an introduction to the elements of co-ordinate geometry, determinations of bending moments and shearing stresses in beams, investigations into the strength of struts, several chapters dealing with stresses in roof and bridge trusses, examination of the stability of various masonry structures, and miscellaneous problems not considered in the earlier chapters. The course of instruction is very complete, and in the present edition the chapter on struts has been re-written so as to deal with the matter more systematically than at first and to give due prominence to the important effects of eccentric loading, a condition that is not always sufficiently recognised either by practical engineers or by professors and others who write books. Some points in the original text requiring amplification are discussed in an appendix, and as now published this work will be found even more useful than its predecessor as a practical aid to the designer and student.

Elementary Microscopy. By F. SHILLINGTON SCALES. (London: Ballière Tindall and Cox.) 3s. net.

The microscope is a means to an end rather than an end in itself, and it must be admitted that many users know comparatively little of the construction of the instrument. To such this work will prove a boon, in that it treats the microscope and certain accessories in clear and terse fashion. The treatment throughout is excellent, and we strongly recommend a perusal of this work to all who use a microscope but who have not time to study the more elaborate treatises. Whilst the author does not treat the microscope as an adjunct in engineering or metallurgy, his work has very direct bearing on these applications, and metallographists especially will find within it much of value.

Water Softening and Treatment, Condensing Plant, Feed Pumps and Heaters for Steam Users and Manufacturers. By WM. H. BOOTH, M.Am.Soc.C.E. (London: Archibald Constable & Co., Ltd., 16, James Street, Haymarket.) 1906. Price, 7s. 6d. net.

The treatment of water for steam-boiler and manufacturing purposes is a question of prime importance to the steam user, who unfortunately understands too little of even the simple reactions and the commercial reagents involved in the prevention of hard scale in his boilers. To all such this volume will prove a valuable acquisition, as it is essentially a practical treatise, no attempt being made to enter too deeply into finer points of chemistry.

The volume is divided into two sections, the first being devoted to the general treatment of water for the steam user. The range of this section is indicated by the titles to chapters, among which may be noted:—Water: Its Sources and Impurities—The Salts contained in Water—The Reactions of Salts in Solution—Scale and its Effects—Water Analysis—Apparatus in Commercial Use — Oil Separation — Boiler Cleaners, &c. The second part of the book deals with condensing plant, feed pumps and heaters, and water coolers. There are many useful tables interspersed in the text, while the illustrations are clear and good.

Tunnel Shields and the Use of Compressed Air in Subaqueous Works. By W. C. COPPERTHWAITE, M.Inst.C.E., Bridges Engineer of the London County Council, with 260 illustrations and diagrams. (London: Archibald Constable & Co., Ltd., James Street, Haymarket.) 1906. Price, 31s. 6d. net.

In view of the prominence that shield work has taken in the British tunnelling operations of recent years—the length of tunnels so constructed in this country is many times greater than the total amount of similar work elsewhere—it is surprising that hitherto no account of such work worth mentioning exists, except in monographs scattered through the proceedings of technical institutions, or in papers that have appeared in the Engineering Press.

The volume under notice will be doubly welcomed by tunnel engineers and others, not merely by the fact that a great deal of the valuable experience acquired by the author when acting as resident engineer of the Central London Railway and of the Greenwich Footway Tunnel is therein embodied, but that it contains a mass of information hitherto difficult and troublesome of access. It is difficult to speak too highly of a work which forms a compendious

history of "Greathead" shield work, the assisted shield method and recent developments generally, and the thorough and masterly way in which the subject is treated will render it indispensable to the profession.

The first chapter deals with the early history of the shield from the time of Brunel's patent of 1818 to Greathead and the introduction of shield work in recent years.

Compressed air and notes on caisson sickness are dealt with in Chapter II., Cast Iron Tunnel Linings forming the subject-matter of the next twenty-eight pages. The titles of succeeding chapters are as follows:—The "Greathead" Shield in London Clay — The Shield in Water-Bearing Strata—The Assisted Shield—The Shield in Masonry Tunnels — Recent Tunnelling Work carried out with a Shield or with Compressed Air and the Cost of the Shield. It is impossible within the limits of space at disposal to indicate the scope of the volume more than to state that every undertaking of importance involving the use of shield or compressed air at home, in France, and the United States has been dealt with, the text being embellished by well-executed illustrations, of which there are no less than 257. Both author and publisher are to be congratulated on the appearance of this admirable work.

Single-Phase Commutator Motors. By FRANKLIN PUNGA. Translated from the German by R. F. Looser, A.M.I.E.E. (London: Whittaker & Co., 2 White Hart Street, E.C.) 1906. Price, 4s. 6d. net.

In the opening chapters of this valuable treatise the origin and nature of sparking—so important a question in connection with single-phase motors—is gone into, particular attention being paid to the method of reducing it by inserting resistances in the commutator leads. A useful chapter is that devoted to a method of computing the reaction of the commutating coils upon the field flux—a reaction which hitherto has hardly received the attention it deserves. Six chapters are devoted to the general theory of single-phase commutator motors, and in the last, a series, repulsion and compensated repulsion motor are calculated through. An appendix is given up to a detailed theoretical investigation of the repulsion motor. To those not mathematically inclined the book will be particularly welcomed.

Modern Steam Road Wagons. By W. NORRIS, A.M.Inst.C.E., M.I.Mech.E. (London: Longmans, Green & Co., 39, Paternoster Row, E.C.) 1906. Price, 7s. 6d. net.

In view of the recent rapid developments that have taken place in the construction of steam road vehicles, such a volume as that by Mr. Norris was badly needed, in fact no publication has hitherto existed which dealt exclusively with the subject of heavy steam motor wagons. The author has succeeded in producing a very readable and valuable work which should interest manufacturers and readers alike; the former particularly, in that particular attention has been devoted to constructional details. Illustrations have been extensively made use of, the majority of the drawings being new and well executed.

Tables for the Use of Blacksmiths and Forgers. By JOHN WATSON, Lecturer in Engineering for Ayr County Committee. (London: Longmans, Green & Co., 39, Paternoster Row, E.C.) 1906. Price, 2s. 6d. net.

In this little volume there is tabulated in convenient form, the results of nearly every possible drawing down or staving operation of round, square and flat sections of all sizes; also tables for hoop lengths and the weights of steel and iron bars for a large range of sections. Instructions on estimating weight are also given. For enabling young smiths to make the necessary calculations relating to their work, this little book will be found invaluable.

Practical Telephony: Adapted to the Requirements of the City and Guilds of the London Institute and the Post Office Departmental Examination. By JAS. BELL, A.I.E.E., and S. WILSON, A.M.I.E.E. (London: S. Rentell & Co., Ltd., 36, Maiden Lane, W.C.) 1906. Price, 3s. 6d. net.

This, the fourth edition of a treatise written specially for telegraph and telephone employees, has been brought thoroughly up to-date, and students cannot fail to find it extremely useful.

The Chemistry of Materials of Engineering. By A. H. SEXTON, F.C.S., F.I.C. (Manchester: The Technical Publishing Co., Ltd., 287, Deansgate.) Price, 5s. net.

This book, which is essentially one for the student, has enjoyed, and deservedly so, a wide popularity. This, the second edition, has been revised and partially re-written, and a useful feature in the shape of an index added. In its revised form it will more than ever be appreciated as an introduction to the larger treatises on the subject.

Electro-Thermic Processes for the Smelting of Ores and the Production of Steel. OTTAWA: Report issued by the Superintendent of Mines' Office.

The Canadian Government are undertaking a practical investigation of electro thermic processes at Sault Ste Marie, and the results should be of very direct value to all interested in metallurgy. A sum of $15,000 has been devoted to this purpose and The Consolidated Lake Superior Power Company have agreed to furnish 400 electric horse power for four months free of cost. In anticipation of these results we

have been led to re-examine the report of the commission appointed last year to investigate electro-thermic processes at work in Europe. It will be remembered that this commission was led by Dr. Eugene Haanel, and included an electrician, draughtsman and secretary, and on arrival in England, Mr. F. W. Harboard, consulting metallurgist to the Indian Government was appointed as metallurgist.

The labours of this commission have resulted in a bulky but most interesting report, which comprises descriptions of the "Kjellin," "Héroult," "Stassano Keller," "Harmet" and "Gustave Gin" processes, together with several valuable appendices. Each process is illustrated by admirable photographs or drawings, and full details as to the type of furnace employed, consumption of energy, working costs, &c., are supplied.

Naturally, electro-thermic processes must be regarded from a two-fold point of view, physical and metallurgical, but as the former is subservient to the latter, we for the present confine our examination to the aspect given in the remarks of the metallurgist as embodied in pages 59 to 116. We need not add that this section of the report possesses a keen interest, which is intensified by the gradually increasing importance of electro-thermic processes. These processes have a distinct future, and under certain conditions even to-day may be made to yield commercial results. Generally, however, the results are such as to render competition with present methods almost out of question. Thus the investigations detailed in the report show in each case a quality of product quite equal to that normally obtained. For example, the "Kjellin" process is stated to yield a product equal to that of crucible cast steel, a statement amply confirmed by the tests and analyses recorded. Essentially, this process is similar to the crucible in that the final product is determined by the materials charged, the difference being found in the method of heating.

Examples of steel making, or "refining" as termed in the report, and of direct smelting are given. Excluding one or two minor accidents the properties of the metal produced in each case were quite up to normal standard, which is eminently satisfactory.

This section of the report terminates by a series of conclusions which aptly summarise the preceding matter. The first of these conclusions reads:—

"Steel, equal in all respects to best Sheffield crucible steel can be produced, either by the 'Kjellin,' 'Héroult' or 'Keller' processes at a cost considerably less than the cost of producing a high class crucible steel."

To this one might reply that steel of crucible quality is produced in the open hearth furnace at a cost considerably less than that of any electro-thermic process.

The second conclusion, which is the only one we shall at present note, reads as follows:—

"At present, structural steels, to compete with Siemens or Bessemer steel, cannot be economically produced in electric furnaces, and such furnaces can be used commercially for the production of only very high class steel for special purposes."

It has been shown that the quality of the steels examined is quite equal to that of normally produced material, but no weighty evidence is offered to show that the quality of an electric furnace product *exceeds* that of a blast furnace, in the case of pig iron, or an open hearth furnace in the case of steel. A suitably manipulated open hearth furnace can be made to yield a product of exceedingly high quality at a comparatively low cost of production.

The question is therefore narrowed down to that of cost, and as far as the iron and steel making centres of Britain, Germany and the United States are concerned, gas fuel is decidedly cheaper than electric energy. In these districts, blast furnaces, operated entirely by coke, will also for some time prove more economical than electro-thermic processes in which coke is solely used as a reducing agent. In the case of an abundant ore supply, with only a limited amount of fuel available, the conditions are reversed, and the question then becomes one of a cheap source of energy. This question is one of peculiar interest to Canada, and the initiation of a series of practical experiments should yield valuable data. The publication of this data will supply definite answers to many issues on which information is at present only to be had from patent specifications. The Canadian Government are to be congratulated on their policy and we trust the experimental results will be published in a similar manner to that of the commission of enquiry.

List of Journals the principal contents of which are regularly indexed. The papers dealt with are those received between the 10th of the month preceding that of publication and the 10th of the previous month.

American Engineer and Railroad Journal, 140, *Nassau Street, New York* ... ... 20 cts.
American Machinist, 218, *William Street, New York* ... ... 4d.
Annales de l'Association des Ingenieurs sortie de Gand, *Rue Longue du Marais, 15, Ghent*... 2 frs. 30 c.
Australian Mining Standard, 31, *Queen Street, Melbourne* ... ... 6d.
Automobile Club Journal, 119, *Piccadilly, W.* 6d.
Automotor Journal, 44, *St. Martin's Lane, W.C.* 3d.
The Autocar, *Coventry* ... ... 3d.

Beton und Eisen, *Kortorung, 14, Vienna I.* ... 2 marks
British Clayworker, 43, *Essex Street, W.C.* ... 6d.
Bulletin de la Société International des Electriciens, 12 & 14, *Rue de Stael, Paris* ... 2 fr. 50 c.

Canadian Engineer, 62, *Church Street, Toronto* 10 cts.
Cassier's Magazine, *New York* 1/-
Centralblatt für Accumulatoren, *Gross Lichterfelde-West, Bellevuestrasse, 40, Berlin* ... 3 mks. 50 pf. per qt.
Colliery Guardian, 30 & 31, *Furnival Street, Holborn, E.C.* ... ... 5d.
Compte Rendu des Travaux de la Société des Ingenieures Civils de France, 9, *Rue Blanche, Paris* ... ... —

Der Mechaniker, 113, *Potsdamerstrasse, Berlin, W.* 35 ... ... 40 pf.
Dingler's Polytechnic Journal, *Berlin* .. ... { 3 mos. 6 mrks.

L'Echo des Mines et de la Metallurgie, *Paris*... 45 fr. p.a.
L'Eclairage Electrique, 40, *Rue des Ecoles, Paris* ... ... 1 fr. 50 c.
Electrical Engineer, 139, *Salisbury Court, E.C.* 3d.
Electrical Review, 4, *Ludgate Hill, E.C.* ... 6d.
Electrical Review, N.Y., 41, *Park Row, New York, U.S.A.* ... ... 10 cts.
Electrical Times, 8, *Breams Buildings, Chancery Lane, E.C.* ... ... 2d.
The Electrician, 1/3, *Salisbury Court, E.C.* ... 6d.
L'Electricien, 18, *Rue des Fossés, St. Jacques, Paris* ... ... 50 cts.
Electricity, 36, *Maiden Lane, W.C.* ... ... 1d.
Electrochemical and Metallurgical Industry, *New York* ... ... 25 cts.
Der Electro Techniker, *Hengasse, 62, Vienna*... 60 pfs.
Elektrische Bahnen U. Betriebe, 8, *Gluckstrasse, Munich* ... ... { 16 mks. p.a.
Elektrotechnik und Maschinenbau, 7, *Nibelungenstrasse, 7, Vienna* ... ... 20 fr. p.a.
Elektrotechnische Rundschau, *Heerdtstr*, 108, *Dusseldorf*, ... 6 mks. 6 mos.
Elektrotechnische Zeitschrift, *Monbijonplatz, 3, Berlin, N. 24* ... ... 70 pf.
L'Elettricita, *Via Boccaccio, 5, Milan* ... ... 50 cts.
The Engineer, 33, *Norfolk Street, W.C.*... ... 6d.
Engineering, 35/36, *Bedford Street, W.C.* ... 6d.
Engineering and Mining Journal, 253, *Broadway, New York* ... . 5 dols. per ann.
Engineering Magazine, 223, *Strand, W.C.* ... 1/-
Engineering News, 220, *Broadway, New York* 15 cts.
Engineering Record, 114, *Liberty Street, New York* ... ... 12 cts.

The Foundry, *Cleveland, Ohio, U.S.A.*... ... 15 cts.

Gas World, 3, *Ludgate Circus Buildings, E.C.* 4d.
Le Génie Civil, 6, *Rue de la Chaussee d'Antin, Paris* ... ... 1 fr.
Giesserei-Zeitung, *Jerusalemer Strasse*, 46/47, *Berlin, S.W.* ... ... 40 pf.
Gluckauf, *Essen, A. D. Ruhr, Germany* 1 mk. 25 pf.

La Houille Blanche, *Grande-Rue*, 23, *Grenoble* 1 fr. 25 c.

Iron and Coal Trades Review, 165, *Strand, W.C.* 6d.
Iron and Steel Magazine, 446, *Tremount Street, Boston* ... ... 50 cts.
Iron and Steel Trades' Journal, 5, *Hatton Garden, E.C.* ... ... 3d.
Iron Trade Review, *Cleveland, Ohio* ... ... { 4 dols. 50 c. p.a.

Journal American Society of Naval Enigneers, *Washington* ... ... 5 dols. p.a.
Journal of the Association of Engineering Societies, *Philadelphia, Pa.* ... ... —
Journal of the Chemical, Metallurgical and Mining Society, *Johannesburg, S.A.* ... 2/-
Journal of the Franklin Institute, *Philadelphia, U.S.A.* ... ... 30 cts.
Journal of Gas Lighting, 11, *Bolt Court, Fleet Street, E.C.* ... ... 6d.
Journal of the Institution of Electrical Engineers, 92, *Victoria Street, S.W.* Single copies vary 1/6-7/6
Journal of the Iron and Steel Institute, 28, *Victoria Street, S.W.* ... ... 16/- per vol. 2 annually
Journal of the Royal Artillery, *Royal Artillery Institution, Woolwich* 2/6
Journal of the Society of Arts, *John Street, Adelphi, W.C.* ... ... 6d.
Journal of the Western Society of Engineers, *Chicago, U.S.A.*... ... ... 50 cts.

Die Lokomotive, *IV. Muhlgasse*, 7, *Vienna* ... 40 h.
La Locomotion Automobile, 15, *Rue Bouchu, Paris* ... ... 50 cts.

La Machine, 11 *Rue de la Dole, Geneva* ... ... { 4 frs. 6 mos.
Machinery, 66, 70, *West Broadway, New York* 25 cts.
Marine Engineer, 3, *Amen Corner, Paternoster Row, E.C.*... ... ... 4d.
Marine Engineering, 17, *Battery Place, New York* ... ... 20 cts.
Mechanical Engineer, 53, *New Bailey Street, Manchester* ... ... 3d.
Mechanical World, 65, *King Street, Manchester* 1d.
Die Metallurgie, *Ludurgsallee*, 15, *Auchen, Germany* ... ... 40 pfg.
Mines and Minerals, *Scranton, Pa., U.S.A.* ... 20 cts.
Mining World, *Chicago* ... ... 10 cts.
Mining Magazine, 120, *Liberty St., New York*... 20 cts.
Mettheilungen des Vereines für die Forderung des Local und Strassenbahnvesens, *Elisabethstrasse, Vienna* ... ... —
Le Mois Scientifique, 8, *Rue Nouvelle, Paris* ... 1 fr. 50 c.

Nature, *St. Martin's Street, W.C.* ... ... 6d.

Physical Review, *Ithaca, New York, U.S.A.* ... 50 cts.
Power, *World Building, New York* ... ... 20 cts.
Practical Engineer, 287, *Deansgate, Manchester* 2d.
Proceedings of the American Society of Civil Engineers, 220, *West 57th Street, New York* } Mbrs. only.
Proceedings of the Canadian Society of Civil Engineers, 112, *Mansfield Street, Montreal* } Mbrs. only.
Proceedings of the Engineers' Club of Philadelphia, 1122, *Girard Street, Philadelphia* ... } 2 dols. per vol.
Proceedings of the Engineers' Society of West Pennsylvania, *Pittsburg, Pa.*... ... ... 50 cts.
Proceedings of the Faraday Society, 82, *Victoria Street, S.W.* ... ... 6d.
Proceedings of the Institution of Civil Engineers, *Great George Street, Westminster* } Mbrs. only.
Proceedings of the Institution of Mechanical Engineers, *Storey's Gate, Westminster* ... } Mbrs. only.
Proceedings of the Royal Philosophical Society of Glasgow, *Glasgow* ... ... 10/6 p.a.
Public Health Engineer, 50/52, *Ludgate Hill, E.C.* ... ... 3d.
Public Works, 22, *Bride Lane, E.C.* ... ... Qtly. 2/6

Quarry, 49, *Essex Street, W.C.* ... ... 6d.

The Railway Age, *Monadnock Block, Chicago*... 10 cts.
Railway Engineer, 3, *Ludgate Circus Buildings, E.C.* ... ... 6d.
The Railway and Engineering Review, 1305, *Manhattan Building, Chicago* ... ... 10 cts.
Railway Gazette, *Queen Anne Chambers, Westminster* ... ... 6d.
Railway and Locomotive Engineering, 136, *Liberty Street, New York* ... ... 2 cts.
The Railway Master Mechanic, 409, 410, *Security Building, Chicago* ... ... 10 cts.
La Revue de Metallurgie, 75, *Rue Notre Dame des Champs, Paris* ... ... 4 fr. 50 c.
La Revue Technique, Paris ... ... 1 fr.

School of Mines, Quarterly, *Columbia University, New York, U.S.A.* ... ... 50 cts.
Scientific American, 361, *Broadway, New York* 8 cts.

Stahl & Eisen, 5, *Jacobstrasse, Dusseldorf* ... } 24 mks. p.a.
The Steamship, 2, *Custom House Chambers, Leith, N.B.* ... ... 6d.
Stevens' Institute Indicator, *Hoboken, N. Jersey* 50 cts.
Street Railway Journal, 120, *Liberty Street, New York* ... ... 6d.

Technology Quarterly, *Institute of Technology, Boston, Mass.* ... ... 75 cts.
"Times" Engineering Supplement ... ... 3d.
Tramway and Railway World, *Amberley House, Norfolk Street, W.C.* 1/-
Transactions of the American Institution of Electrical Engineers, 26, *Cortlandt Street, New York* ... ... Price varies.
Transactions of the American Institution of Mining Engineers, 99, *John St., New York* Price varies.
Transactions of the American Society of Mechanical Engineers, 12, *West 31st Street, New York* ... ... Mbrs. only.
Transactions of the Civil and Mechanical Engineers' Society, *Victoria Street, S.W.* Mbrs. only.
Transactions of the Engineers and Shipbuilders in Scotland, *Glasgow* ... ... Price varies.
Transactions of the Institution of Junior Engineers, 39, *Victoria Street, S.W.* ... —
Transactions Liverpool Engineering Society, *Royal Institution, Liverpool* ... ... —
Transactions N.E. Coast Institution Engineers and Shipbuilders, *Newcastle-on-Tyne* ... —
Transactions of North of England Institution of Mining and Mechanical Engineers, *Newcastle-on-Tyne* ... ... —
Transactions of the Society of Engineers, *Victoria Street, S W.* ... ... Mbrs. only.
Transactions Society of Manchester Engineers, 29, *Brown Street, Manchester* ... ... —

Western Electrician, *Chicago* ... ... 10 cts.

Zeitschrift des Oestereichischen Ingenieur und Architekten Vereines 1, *Exchenbachgasse, Vienna*, 9... ... ... 70 h.
Zeitschrift des Vereines Deutscher Ingenieure, *Berlin* ... ... 1 m. 40 pf.

Civil Engineering.

Construction of the Lateral Moldau Canal from from Wranan to Horin. *Zeitsch. des. Oesterreich Ingr. und Arch. Vereines*, 30*th March*, 1906.

Basle Bridge. *Engineer*, 20*th April*, 1906.

The Washington Street Tunnel of the Boston Subway System. *Engineering News*, 19*th April*, 1906.

Pier for the L.C.C. Tramway Power-Station, Greenwich. *Engineering*, 27*th April*, 1906.

The Anatomy of Bridgework, XIII. By W. H. Thorpe. Life of Bridges. Relative Merits. *Engineering*, 27*th April*, 1906.

Coast Erosion and Reclamation, I., II. *Engineer*, 27*th April* and 4*th May*, 1906.

The Design of Swing Bridges from a Maintenance Standpoint. Abstract of Paper by C. H. Cartlidge before *Western Society Engineers*, 18*th April*. *Engineering News*, 26*th April*, 1906.

"Horseshoe" Concrete Arches. By D. E. Luten. *Railway Gazette*, 4*th May*, 1906.

Reinforced Concrete Piles in Tidal Waters. By A. F. Walmisley, M. Inst. C.E. *Concrete and Constructional Engineering*, *May*, 1906.

Concerning the Investigation of Overloaded Bridges. *Transactions American Society Civil Engineers*, *April*, 1906

The Distribution of Loads on Stringers of Highway Bridges Carrying Electric Cars. *Engineering News*, 12*th April*, 1906.

The Pennsylvania Railroad Bridge at Havre de Grace. *Engineering Record*, 28*th April*, 1906.

A New Method of Rock Tunneling under City Streets. *Engineering News*, 5*th April*, 1906.

Concrete Retaining Wall on the Hirschberg-Lahn Railway. *Beton und Eisen*, *April*, 1906.

Building.

Roof of the Turbine House at Chèvres, Geneva. *Beton und Eisen*, *April*, 1906.

Heating and Ventilating.

Heating and Ventilation. *Engineer*, *Chicago*, 2*nd April*, 1906.

Vapour-Vacuum Heating, By James A. Donnelly Abstract of Paper before American Society Heating and Ventilating Engineers. *Engineer*, *Chicago*, 16*th April*, 1906.

Materials and Measurements.

Load Test of a Ferro-concrete roof. *Beton und Eisen, April*, 1906.

The Setting of Portland Cement, I., Part B. By Cecil H. Desch. *Concrete and Constructional Engineering, May*, 1906.

The Preservation of Iron and Steel against Corrosion, Part B. By B. H. Thwaite, C.E. *Concrete and Constructional Engineering, May*, 1906.

Effect of Clay upon the Strength of Cement Concrete. *The Quarry, May*, 1906.

New Method of Determining Maximum Strength of Rods in Statically Determined Lattice Work. *Zeitsch. des Oesterreich Ingr. und Arch. Vereines, 4th May*, 1906.

Boilers, Furnaces and Fuel.

Smoke Prevention in the Modern Power Station. By J. B. C. Kershaw. *Mechanical World, 20th April*, 1906.

Central Station Boiler-Room Losses. *Electrical Engineer, 4th May*, 1906.

Steam Power Generation (continued). *Practical Engineer, 13th April*, 1906.

Some Notes on Steam Boilers, II. By R. L. Kennett. Riveting and Bracing. *Power, April*, 1906.

Engines and Motors.

Turbine Pumps with Balanced Impellers. *Engineering News, 5th April*, 1906.

Steam Turbine Dynamos. By A. G. Ellis (concluded). *Electrical Times, 12th April*, 1906.

Electro-magnetic Control of Governors. H. B. Speyer. *Electrical Engineer, 20th April*, 1906.

Steam Consumption of Winding Engines. *Engineer, 13th April*, 1906.

Heat analysis of a Gasoline Engine (concluded). *Engineer, Chicago, 16th April*, 1906.

An Injector Theory. *Engineer, Chicago, 16th April*, 1906.

Modern Steam Traps. *Practical Engineer, 13th* and *27th April*, 1906.

The Nicholson Automatic Engine Stop. *Engineering and Mining Journal, 21st April*, 1906.

Some Practical Experiences with Steam Turbines. By C. E. Stanton. *Street Railway Journal, 28th April*, 1906.

A Heated Piston Engine. C. R. King. *Machinery, April*, 1906.

Condensing Machinery for Steam Turbines. *Engineering, 20th April*, 1906.

Engine Barring Gear, III. *Mechanical World, 4th May*, 1906.

Gas, Oil, and Petrol Engines (continued). By H. N. Bickerton. *Mechanical World, 13th April*, 1906.

The Ventilation of Turbo-Dynamos. *Elek. u. Maschinenbau, 22nd April*, 1906.

Theory of Turbines and Centrifugal Pumps. *Zeitsch. des Vereines Deutscher Ingr, 14th April*, 1906.

Turbine Design as Modified for Close Regulation. By G. A. Bavinger. *Proceedings American Society Mechanical Engineers*, Vol. xxvii., No. iv.

Efficiency Tests of Turbine Water Wheels. Wm. O. Webber. *Proceedings American Society Mechanical Engineers*, Vol. xxvii., No. iv.

Gas Turbines. *Bulletin de la Société des Ingenieurs Civils de France, February*, 1906.

Notes on Motors and Gas Turbines. By M. J. Deschamps. *Bulletin de la Société des Ingenieurs Civils de France, February*, 1906.

Hydraulics and Compressed Air.

Air Compressors and Blowing Engines. By C. H. Innes (continued). *Practical Engineer, 20th April* and *4th May* 1906.

Speed Regulation of Water Power Plants. John Sturgess. *Proceedings American Society Mechanical Engineers*, Vol. xxvii., No. iv.

Regulation of High Pressure Water Wheels for Power Transmission Plants. George J. Henry, Junior. *Proceedings American Society Mechanical Engineers*, Vol. xxvii., No. iv.

Shop Equipment and Practice.

New Broaching Machine. *American Machinist, 28th April*, 1906.

Machine Tool Design, XVIII. Theory of all Gear Headstocks. By Prof. J. T. Nicolson and Mr. Dempster Smith. *Engineer, 27th April*, 1906.

Designing a Boring Mill. *American Machinist, 28th April*, 1906.

Milling Cutters. *Machinery, April*, 1906.

History of the Introduction of a System of Shop Management. *Proceedings American Society Mechanical Engineers*, Vol. xxvii., No. iv.

Report of Committee on Standard Proportions for Machine Screws. *Proceedings American Society Mechanical Engineers*, Vol. xxvii., No. iv.

Progress in German Manchine Tools. *Zeitsch. des Vereines Deutscher Ingr., 14th April*, 1906.

Miscellaneous Mechanical Subjects.

Calculating coiled Springs for Electrical and Mechanical Apparatus. *Elek. und. Maschinenbau, 29th April*, 1906.

Design of Condensing Plant. *Mechanical World, 20th April*, 1906.

Centrifugal Fans, Abstract of Paper by Thomas H. Johnson, before *Engineers' Society, West Pennsylvania. Mechanical World, 27th April*, 1906.

Mechanical Engineering Materials: Their Properties and Treatment in Construction. III., Wrought or Finished Iron, by Ed. C. R. Marks. *Practical Engineer, 27th April*, 1906.

Power Transmitted by Worm Gearing. *American Machinist, 5th May*, 1906.

Refuse Destructors, by Mr. H. Norman Leask. *Transactions Institute Engineers and Shipbuilders in Scotland*, Vol. xlix., Part vi.

Disposal of Municipal Refuse and Rubbish Incineration. *Transactions of the American Society of Civil Engineers, April*, 1906.

Overwinding in Hoisting Operations. *School Mines Quarterly, January*, 1906.

Theory and Practice of Lubrication. Theory of Lubrication and Phenomena of Seizing. *Automobile Club Journal, 3rd May*, 1906.

The Application of Ball Bearings to Electrical Machinery, I., II., by C. Kinzbrunner, *Mechanical World, 13th* and *27th April*, 1906.

Separation of Oil fr m Feed Water. J. H. Harwood. *Electrical Review, 13th April*, 1906.

A New Wire Rope Testing Machine. *Iron and Coal Trades Review, 4th May*, 1906.

Power Required to Thread Pipes. Abstract of Paper by T. N. Thomson, before American Society of Heating and Ventilating Engineers. *Engineering, Chicago, 2nd April*, 1906.

Endless Wire-Rope Drives. By Wm. Hewitt. *Stevens' Institute Indicator, April*, 1906.

Collapsing Pressures of Bessemer Steel Lap-Welded Tubes, three to ten inches in diameter. *Proceedings American Society Mechanical Engineers*, Vol. xxvii., No. iii.

Mechanics in relation to Machine Construction. *Zeitsch. des Vereines Deutscher Ingr. 28th April*, 1906.

Railway and Locomotive Engineering.

Development of Valve and Valve Motion. By A. Sinclair, II. *Railway and Locomotive Engineering. April*, 1906

A Ten Year's Record of Locomotive Failure. *American Engineering and Railroad Journal, April*, 1906.

The Mellin Compound. *American Engineering and Railroad Journal, April*, 1906.

The Gauge of Colonial Railways. *Engineering, 13th April*, 1906.

Compound Locomotives. By G. R. Sisterson. *Engineering, 27th April*, 1906.

The Cast Steel Cylinders. *Railway Gazette, 4th May*, 1906.

Line and Surface, I. By M. Burpee, Chief Engineer Bangor and Aroostock Railroad. *Railway and Engineering Review, 21st April*, 1906.

Recent Experience with Superheated Steam on Canadian Pacific Railway Locomotives. *Engineering News, 26th April*, 1906.

New Great Northern Water Scoops. *Railway Gazette, 20th April*, 1906.

The "Robert" Locomotive Water-Tube Boiler, Paris, Lyons, and Mediterranean Railway. *Railway Gazette, 20th April*, 1906.

Test of the Sauvage Air Brake. By George L. Fowler. *Railway Gazette, 20th April*, 1906.

Reinforced Concrete on the G.W.R. *Concrete and Constructional Engineering, May*, 1906.

Report of Committee Co-operating on Pennsylvania Railroad Locomotive Tests. *Proceedings of the American Society of Mechanical Engineers*, Vol. xxvii., No. iii., 1906.

Locomotives at the Liège Exhibition. *Proceedings Societé des Ingenieurs Civils de France, May*, 1906.

The Powell-Potter System of Automatic Control of Trains. *Railway and Engineering Review, 7th April*, 1906.

New German Express Engines. *Zeitsch. des Vereines Deutscher Ingr., 14th April*, 1906.

Automobilism and Road Traction.

Hauling Passengers and Goods by Heavy Motor Cars. *Zeitsch. des Vereines Deutscher Ingr., 5th May*, 1906.

The Field of the Electric Tramway and Motor Omnibus. Discussion on Mr. E. Manville's Paper. *Automobile Club Journal, 12th April*, 1906.

The 35 h.-p. Napier Petrol Bus. *Automotor Journal, 28th April*, 1906.

The 1906 Hotchkiss Cars. *Automotor Journal, 28th April*, 1906.

Ignition Timing and Power Production. By Chas. S. Lomes. *Autocar, 28th April*, 1906.

The Humphrey-Scowen Gear Mechanism. *Autocar, 28th April*, 1906.

The Austin 20-30 h.-p. Car. *Autocar. 28th April*, 1906.

Automobile Construction, IX. By F. C. Mason. *American Machinist, 28th April*, 1906.

The Humber Petrol Cars, Four and Six-Cylinder Models, (concluded). *Automotor Journal, 21st April*, 1906.

The 25, 30, and 35-40 h.-p. Iris Cars. *Autocar, 14th April*, 1906.

The Four-Cylinder Cadillac, a New Vertical Model. *Automotor Journal, 14th April*, 1906.

The Korting Paraffin Engine. *Autocar, 5th May*, 1906.

The Antoinette Engine. *Automotor Journal, 5th May*, 1906.

The Hedgeland Solid Live-Axle. *Automotor Journal, 14th April*, 1906.

The 30 h.-p. Wolseley 'Bus (Vertical Type). *Automotor Journal, 5th May*, 1906.

The Austin Petrol Cars, I. *Automotor Journal, 5th May*, 1906.

Two recent types of American Traction Engines. By W. Fletcher. *Practical Engineer 13th April*, 1906.

Special Steels for Motor Car Construction. Nickel Alloys. *Motor Traction, 2nd May*, 1906.

Motor Car Traffic and Tramways. *Elek. Bahnen u. Betriebe, 24th April*, 1906.

Electric Lighting.

Notes on Wiring with Lead Covered Rubber-Insulated Wire. *Electrical Review, 20th April*, 1906.

The Artificial Lighting of Works. *Mechanical World, 20th April*, 1906.

Electric Lighting at Stoke Newington. *Electrician, 20th April*, 1906.

Electric Lighting and Conflagrations. *Elek. und Maschinenbau, 29th April*, 1906.

Electrical Generation and Transmission.

Notes on the Distribution of the Magnetic Flux in Direct-current Machines, with Commutating Poles. *Electrical Engineer*, 20th *April*, 1906.

Generators of 10,000 h.-p. on Vertical and Horizontal Shafts. *Western Electrician*, 7th *April*, 1906.

The Bille Central Station at Hamburg, Germany. *Western Electrician*, 14th *April*, 1906.

Influence of Load Factor on Hydro-electric Installation. *Western Electrician*, 31st *March*, 1906.

Switches Operated at a Distance without Separate Wires. *Electrical Review*, 4th *May*, 1906.

The Theory of Shop Methods of Testing Single and Polyphase Transformers. By J. W. Rogers. *Electrical Engineer*, 4th *May*, 1906.

Some Notes on the Regulation of Rotary Converters. By Alf. Still. *Electrical Review*, 13th *April*, 1906.

The Estimation of the Reactanse Voltage of Continuous Current Dynamos. By H. M. Hobart. *Electrician*, 20th *April*, 1906.

Railway Sub-Station Design, Capacity and Location. By S. Woodfield. *Electrical Review*, 20th *April*, 1906.

Regulating Compound-wound Dynamos Operating in Parallel Power. *April*, 1906.

Low Resistance Thermo-electric Pyrometer and Compensator. *Proceedings American Society of Mechanical Engineers*, Vol. xxvii., No. iv.

The Adhesion Weight of Alternating Current Motors. *Elek. Bahnen und Betriebe*, 4th *May*, 1906.

The Hydro-Electric Installations of Upper Italy—Semenza. *La Hoiulle Blanche*, *March*, 1906.

Accumulator Grids. *Centralblat fur Accumulatoren-Technik*, 1st *April*. 1906.

Employment of Automatic Auxiliary Machines in Electrical Works. *Elektrot und Maschenebau*, 8th *April*, 1906.

Electric Traction.

Swiss Electric Railways. *Elek. Bahnen. und Betriche*, 4th *May*, 1906.

Single Phase and Continuous Current Equipments and Limiting Schedule Speeds. By H. M. Hobart. *Tramway and Railway World*, 5th *April*, 1906.

Third Rail Insulators, by E. Goolding. *Tramway and Railway World*, *April*, 1906.

Cavehill and Whitewell Tramways. *Tramway and Railway World*, *April*, 1906.

Durban Municipal Tramways. *Tramway and Railway World*, *April*, 1906.

Electric Traction on Main Line Railways in Europe. By Philip Dawson. *Street Railway Journal*, 7th *April*, 1906.

Overhead Catetnary Construction for the New York, New Haven, and Hartford Railroad, *Street Railway Journal*, 7th *April*, 1906.

The Pennsylvania Railroad's Extension to New York and Long Island. The Long Island City Power Station. *Street Railway Journal*, 7th *April*, 1906.

Effects of a Street Storm on Different Types of Third Rail Protection. *Railway Gazette*, 27th *April*, 1906.

Details of the A.C., D.C. Locomotives for the New York, New Haven, and Hartford Railroad. *Railway Gazette*, 27th *April*, 1906.

The Reconstructed Baltimore System. *Street Railway Journal*, 21st *April*, 1906.

The advantages of the Inter-Pole Motor Design in Railway Motors. By G. Herbert Condict. *Street Railway Journal*, 21st *April*, 1906.

Extensions and Improvements of the Terre Haute Traction and Lighting Company. *Street Railway Journal*, 28th *April*, 1906.

Tne Electrification of the New York Central Terminus, I., II. *Engineer*, 27th *April* and 4th *May*, 1906.

Dundee, Broughty Ferry and District Tramways. *Electrical Engineer*, 4th *May*, 1906.

Seebach Wettingen Single Phase Railway. *Electrician*, 20th *April*, 1906.

Traction Experiments with High Tension Monophase Current on the Reebash-Wettingen Line. *Elektrot. und Maschin*, 8th *April*, 1906.

Miscellaneous Electrical Subjects.

Observations on Telephone Conductors on the Pipsin System. *Elek. und Maschinenbau*, 1st *April*, 8906.

The Electrical Equipment of the Aberdare Collieries of the Powell Duffryn Company. *Electrical Review*, 20th *April*. 1906.

Electrolysis. *Western Electrician*, 7th *April*, 1906.

Electric Cranes. *Mechanical World*, 27th *April*, 1906.

100-Ton Electric Derrick Crane at Spotts' Dock, Greenock. *Engineering*, 27th *April*, 1906.

The Testing of Transformers and Transformer Iron. Abstract of Paper before Institute Electrical Engineers. By D. K. Morris and G. A. Lister. *Electrician*, 27th *April*, 1906.

The Charlottenburg Conference on Electrical Units of Measurement. By H. S. Carhart. *Western Electrician*. 14th *April*, 1906.

Electricity *v.* Compressed Air for Mine Operations. *Mechanical World*, 13th *April*, 1906.

Errors in the use of Electric Motors for Machine Driving. By W. A. Ker. 13th *April*, 1906.

The advantages of Employing Electrical Engineering Nomenclature in Steam Engineering Calculations. By H. M. Hobart. *Electrical Review*, 27th *April*, 1906.

Electric Charging and Discharging Apparatus for Horizontal Gas Retorts. *Elek. Bahnen u. Betriebe*, 12th *April*, 1906.

Marine Engineering and Naval Architecture.

The Overhead Wire Cableway applied to Shipbuilding. By J. L. Twaddell, before Institute of Naval Architects, 6th April, 1906. *Engineering*, 13*th April*, 1906.

French Armoured Cruiser. Ernest Renan. *Engineer*, 20*th April*, 1906.

Ship Model Experimental Tank at the Clydebank Shipyard. *Engineering*, 27*th April*, 1906.

Oil Tight Work in Ships of Light Construction. Paper by Herbert Rowell before Institute of Naval Architects, 6th April, 1906. *Marine Engineer*, 27*th April*, 1906.

Notes on the Freeboard Rules. By J. Foster King, before Institute of Naval Architects. 6th April, 1906. *Engineering*, 27*th April*, 1906.

The Speed of Motor Boats and their Rating for Racing Purposes. Abstract of Paper by Linton Hope, before Institute of Naval Architects. *Automotor Journal*, 21*st April*, 1906.

Propellers, III. By A. E. Seaton. *Marine Engineer*, 4*th May*, 1906.

Submarine Sweeps for Locating Obstructions, in Navigable Waters. *Engineering News*, 26*th April*, 1906.

Cruising Turbines for Warships. By E. S. Fortis. *Times Engineering Supplement*, 18*th April*, 1906.

Submarine Signalling by Means of Sound. By J. B. Willet. *Journal Society of Arts*, 4*th May*, 1906.

Standardisation of Naval Machinery. *Engineering*, 4*th May*, 1906.

Motor Boats, X. By Dr. William F. Durand. *Marine Engineering*, *April*, 1906.

Official Tests of Electrically Operated Bulkhead Doors. *Marine Engineering*, *April*, 1906.

French Armoured Cruisers. *Marine Engineering*, *April*, 1906.

Marine Engine Erection, I. *Mechanical World*, 4*th May*, 1906.

L. C. C. Passenger Steamers. By A. Hogg. *Transactions North East Coast Institute Engineers and Shipbuilders*, *April*, 1906,

Water Supply.

The New Waterworks and Reinforced Concrete Conduit of the City of Mexico. By Jas. D. Schuyler, *Engineering News*, 19*th April*, 1006.

A Large Power-Driven Pipe Tapping Machine with Special Sleeve and Valve Connection. *Engineering News*, 12*th April*, 1906.

The Washington Water Filtration Plant. By E. D. Hardy, Superintendent. *Engineering Record*, 7*th April*, 1906.

Sterilizing Water by Means of Ozone. *Electrical Review*, 13*th April*, 1906.

Sewage.

The Use of Electrolytic Hypochlorite as a Sewage Sterilizing Agent in the United Kidgdom. By J. B. C. Kershaw. *Electro-chemical and Metallurgical Industry*, *April*, 1906.

Levee and Drainage Works at Memphis, with a Pumping Plant having several unusual features. *Engineering Record*, 21*st April*, 1906.

Sewage Purification. *Public Health Engineer*, 14*th April*, 1906.

Streets and Pavements.

Vitrified Brick for Paving Purposes. *Engineering Record*, 14*th April*, 1906.

Engineering Economics and Works Management.

The Commercial Organisation of Engineering Factories, II., III., IV. By H. Spencer. *Engineer*, 13*th* and 27*th April* and 4*th May*, 1906.

Shops Hints for Structural Draftsmen, III. *Engineering News*, 5*th April*, 1906.

Miscellaneous.

Principles and Practice of Coremaking. Abstract of paper by R. Buchanan before Staffordshire Iron and Steel Institute. *Mechanical World*, 20*th April*, 1906.

Conductivity of Vapour from the Mercury Arc. C. D. Child. *Physical Review*, *April*, 1906.

New Liquid Measuring Apparatus. *Proceeedings American Society Mechanical Engineers*. Vol. xxvii., No. 3.

Effects of a Blow. *Proceedings American Society Mechanical Engineers*. Vol. xxvii., No. 3.

Determining the Relation between the Shape of a Bridge and Atmospheric Resistance. *Zeitsch. des Vereines deutscher Ingr.*, 21*st April*, 1906.

NOTICES.

Screw Cutting Indicator. Machinists and amateurs will find this handy indicator of value, in that it shows at a glance what wheels to put on the lathe to cut any desired thread. It is made in three patterns to suit lathes having guide screws of 2, 4, and 8 threads per inch respectively. The 2-thread indicator gives wheels for cutting from $\frac{1}{2}$ to 40 per inch; the 4-thread indicator gives wheels for cutting from $\frac{1}{4}$ to 40 per inch; the 8-thread indicator gives wheels for cutting from 2 to 60 per inch. The rule for calculating wheels is also given, so that any wheels not included in the tables may be readily worked out. Each indicator is enclosed in a neat case to keep it clean when not in use. It is made by Percival Marshall & Co., 26-29, Poppin's Court, E.C., from whom it can be obtained, post free 3*d*.

Corner Curve for Machine Draughtsmen. This handy instrument, made by Messrs. W. J. Brooks & Co., Letchworth, Herts, price 1s., provides an admirable time-saving substitute for compasses for rounding off angles (to indicate

fillets, &c.) in machine drawings and for drawing small curves. Each curve has straight tails, so that it merges without visible join into the straight lines of the drawing. The edge is also raised so that the ink does not run under.

Double Cast-Iron Bar Testing Machine. A machine of this description for foundry use has just been put on the market by Messrs. Samuel Denison and Son, Ltd., Hunslet Foundry, Leeds. This machine, which has no loose weights, is arranged to break cast-iron specimen bars, 2 in. by 1 in., placed edgways under bearings 3 ft. apart; also bars 1 in. square, under bearings 1 ft. apart. The superstructure of the machine is raised complete by a screw operated by hand wheel, and so pulls up at the centre of the specimen, by a connecting rod. The steelyard, or indicating lever, is graduated by dividing engine up to full capacity in cwts. by 14 lbs. divisions, and also in lbs. only. The travelling pose-weight is propelled along the steelyard by means of a screw, operated by a small wheel, and is not touched by the hand. The pose-weight cannot slip forward when the break takes place. The deflection of the specimen is accurately shown on an engraved index-plate. After a test, the pose-weight can quickly be brought back again to zero by its handle, which disengages the nut from the screw.

Messrs. G. R. Speaker & Co., Government Contractors of Market Buildings, Mincing Lane, E.C., intimate that they have been appointed sole concessionaires of the British patent rights for "Eternit" Asbestos Roof Slates and "Eternit" Asbestos Insulating Sheets—materials which are in demand for use in lieu of red roof tiles and the like.

The Linolite Company, of 25, Victoria Street, Westminster, S.W., have just delivered 360 feet of Linolite to Messrs. Waring and Gillows, for part of their new premises in Oxford Street. They have also recently delivered to Messrs. Belshaw & Co. 450 feet for lighting a country house.

The Romapac Tramway Construction Co., Ltd., of 2, East Parade, Leeds, inform us that the Leeds Corporation have placed an order with them for replacing a considerable portion of their worn-out track with the Romapac Patent Renewable Tramrail, and have decided that a length of not less than one mile shall be laid as early as possible. This has been decided upon in consequence of the satisfactory working of a length laid at Headingley last year.

Mr. T. W. Sheffield, A.M.I.M.E., A.M.I.E.E., who opened (and managed for some four or five years) the Manchester Branch of the British Thomson-Houston Company, Ltd., has been appointed manager for Messrs. Crompton & Co., Ltd., to control a larger district, including Lancashire and the north-western counties. Messrs. Crompton's new showrooms and offices in Manchester are at Woodall's Buildings, 42, Deansgate. We understand that Messrs. Crompton & Co., Ltd., have obtained very successful results in the application of the 3-phase system, and they are taking up the question very energetically in connection with the textile industries in Lancashire and Yorkshire. We understand they have opened a special department at the Manchester office to deal with the application of electrical driving for mills and workshops.

NEW CATALOGUES.

O. N. Beck, 11, Queen Victoria Street, E.C. Illustrated circular describing the "Bagmag" Belt Shifter for speed cones. This apparatus consists of a rectangular eye embracing the belt. The eye is placed in a ring in which it can turn and thus adjust itself to any position of the belt. The ring is carried by means of two guide rods, which latter are free to slide through a fixed cross-head. The cross-head is fastened to a spindle supported close to the standing place of the operator and can be rotated. The rod is at a suitable height provided with a handle, by means of which the shifter is actuated. The support of the rod may be effected in the simplest manner by bent flat iron brackets secured partly to the ceiling, etc., and partly to the machine.

Also received a leaflet descriptive of a Universal Pipe Hanging Expander.

Davies & Metcalfe, Ltd., Romiley, near Manchester. Catalogue of exhaust steam injectors for locomotives. This apparatus was fully dealt with in our issue for November, 1903, the text and illustrations being reproduced in the above catalogue.

Kennicott Water Softener Co., 29, Gt. St. Helens, London, E.C. Well illustrated leaflets describing types A. and B. of the Kennicott Water Softener and Purifier. Some of the features of this apparatus may be enumerated, viz., automatic feeding device for reagents; the use of soft water for making lime water; automatic hoist for reagents; constantly moving agitator in the mixing chamber; patent type of downtake or cone which decreases the speed of flow of water downwards, and finally only one pumping is required, viz., that of the hard water into the softener.

H. T. Boothroyd, Hyslop, & Co., Bootle, Lancs. Illustrated price list of continuous current motors and generators.

Hodgson Hartley, Ltd., Little Peter Street, Knott Mill, Manchester. Catalogue "A" of special machine tools, comprising shaping machines, screw and rack planers, boring machines, screwing and wheel cutting and dividing machines. Also pamphlet describing the Brookhouse patent pneumatic sand moulding machine, and lists "E" and "H" of the Tabor indicator.

Ph. Bonvillain and E. Roncevay, 9 and 11, Rue des Envierges, Paris. List of radial drilling machines.

W. H. Bailey & Co., Ltd., Salford. List No. 106 of stationary steam fire engines.

Consolidated Pneumatic Tool Co., Ltd., Palace Chambers, Westminster. Special circular, No. 13, of electrically driven tools and accessories, comprising drills, drilling posts, plug connections, emery grinders, wire rope hoists, and armoured twin flexible cable.

F. Wallis Stoddart, Western Counties Laboratory, Bristol. List of new patterns of distributing apparatus for sewage filters.